THE TECH ENGINEERING NEWS

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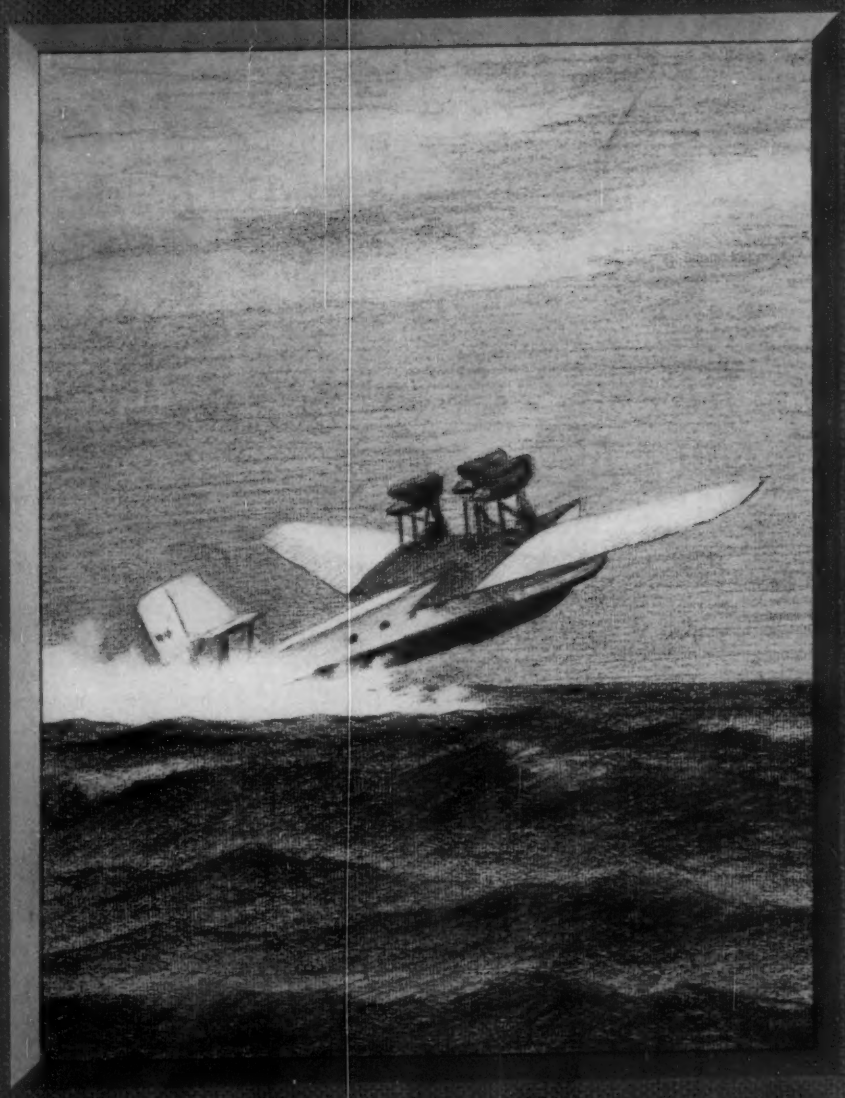

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VOLUME X, NO. 4
MAY, 1929

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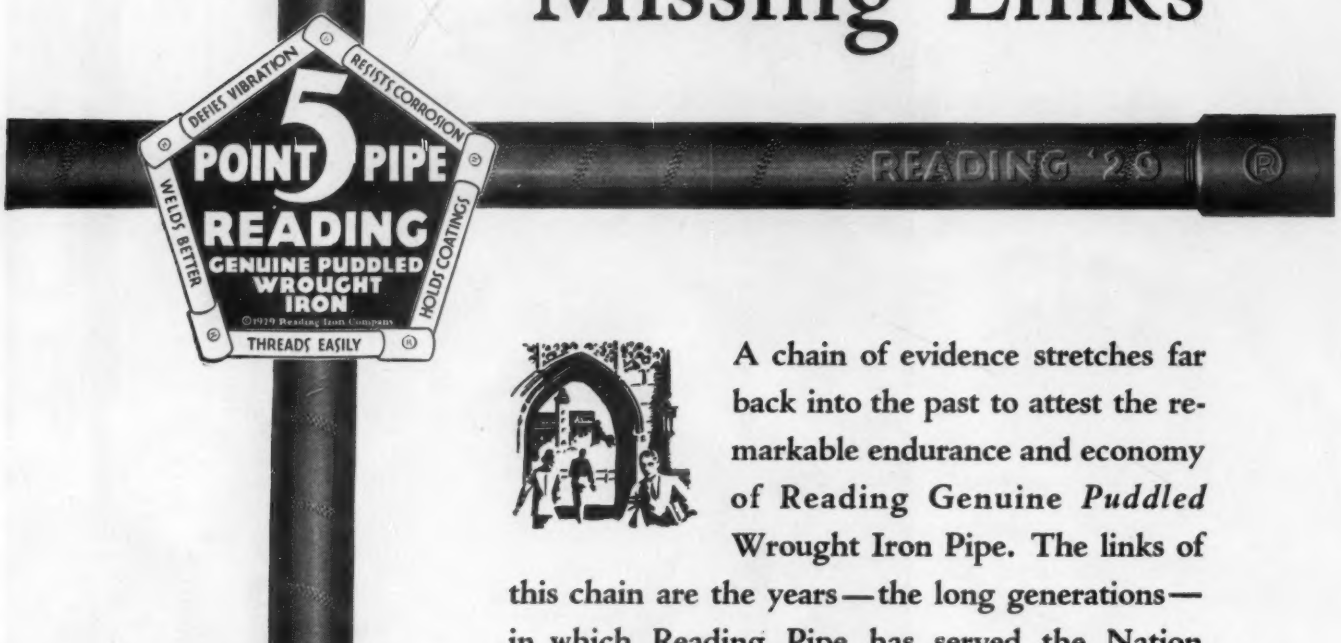

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THE TECH ENGINEERING NEWS

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THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME X | MAY, 1929 | NUMBER 4

The Senior's First Job

The present employment situation and the factors influencing the selection of a position

By FRANK L. LOCKE '86
Personnel Director
Massachusetts Institute of Technology

IN planning for his start in business after graduation, the senior faces a difficult decision. Many are the points to be considered, none perhaps more important than the wise selection of the first position. Fortunate, indeed, are our seniors of 1929, in that the great demand of industry for technically trained men assures practically every graduate of this year's class some definite professional position. Many of our students have already determined the particular lines of work which they wish to undertake, a few have attended M. I. T. definitely to fit themselves for positions waiting for them on graduation. Some, through summer employment in industry, have been able to determine quite clearly the lines of work in which lies their greatest interest, or for which by experience and training they seem best fitted. Those to whom the best field for their future is not quite clear should give the decision careful and intelligent consideration.

Those who happily make a wise first choice have, as a rule, some advantage over those who find it necessary to make readjustment changes in the first years out of college. Readjustments generally mean new starts, with corresponding drops in salary to starting rates, and usually with some loss in the cumulative experience in business routine and industrial practice, this depending of course on the differences between the old and new positions. On the other hand, such changes help those not fully determined as to a career to secure wider experience and perhaps to make a wiser final choice.

Dr. John M. Brewer, head of the Department of Vocational Guidance of Harvard University, mentions the following eight factors as essential in choosing a vocation:

The importance of the vocation to society.

The tasks of the worker.

The advantages to him of the occupation.

As the time for Commencement draws near, members of the graduating class begin to consider their plans and opportunities for the future, and students in the lower years, soon to be faced with the same problem, also take a keen interest in the question of finding employment. Colonel Locke, well qualified by years of experience in the personnel field, gives his opinions and advice on "The Senior's First Job."

The disadvantages and the problems presented by the occupation.

The qualities of character essential.

The preparation required.

The income to be expected.

The effect of the calling on the worker's life.

Technology men happily find this problem simplified through the practical character of our courses of training — the laboratory experience, much of which is on problems definitely related to the latest developments in industry and business, and the association with an instructing staff many of whose members are identified as consultants in the everyday affairs of modern engineering and industrial concerns. He may make use of the occupational information and insight into the affairs of engineering, research and management, given in the Aldred and other lectures by prominent engineers and business executives, and obtained through the recently established course in Humanics under Col. Charles R. Gow.

Of further help are the visits to the Institute of representatives of engineering and industrial concerns for the purpose of acquainting graduates with the opportunities offered for employment, the conditions to be met, and the requirements for positions open.

The number of these visits constantly increases, and the interest shown and the character of industrial representatives testifies to the growing appreciation by industry of the importance both for itself and for our graduates of careful thought in fitting for and choosing the life's work.

For this school year, visits began as early as November, and since the first of February it may be said safely that no day has passed without a visit of some representative or an inquiry by mail or telephone requesting contact with men seeking positions.

Recognizing the value both to industrial representatives and to educational departments of direct contact, it is planned as far as possible that interviews be arranged directly by the several educational departments, the Personnel Office assisting through the supply of conference rooms, clerical service, the scheduling of interviews and in general service as a coördinating agency.

(*Continued on page 158*)

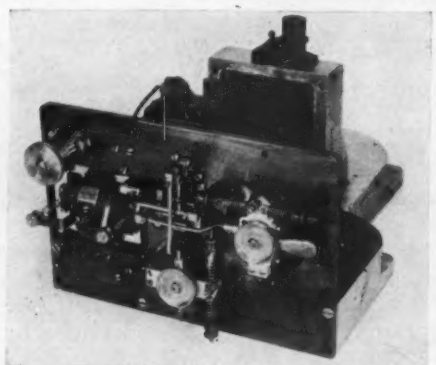
Industrial Physics

Because of the growing importance of physics in industry, the Institute has recently modified its course in this subject

By CHARLES LADD NORTON, '93
Professor of Industrial Physics
Head of the Department of Physics
Massachusetts Institute of Technology

THE recent changes which have been made in the schedule of Course VIII call attention to the modifications which have been made from time to time in the teaching of physics at the Massachusetts Institute of Technology. The new schedule is designed to give greater freedom to the student in physics so that he may fit himself more definitely for some particular line of work, whether it be theoretical physics or physics applied to the problems of industry.

The term Industrial Physics as applied to a subdivision of professional work is comparatively new. A considerable time had elapsed since the general recognition of industrial chemistry and the beginning of the training of industrial chemists, before the similar development in physics began. For a long time it had been said that the various branches of engineering were really the industrial developments of physics, and that there was no real call for men especially trained in industrial physics.



A MACHINE FOR MEASURING ANGULAR VELOCITIES AROUND THREE AXES

This is a typical research instrument such as men trained in Industrial Physics are called upon to develop.

The systematic training of such men at Technology began in 1914, with the establishment of a Laboratory of Industrial Physics and the Professorship of Industrial Physics, which has since been held by the writer. The purpose of the instruction was to train men in physics with some knowledge of industrial problems and practical methods of working them out. It was believed that such instruction should concern itself essentially with physical problems, phenomena, and principles, rather than with the operation of equipment or personnel, for the accomplishment of physical results, the latter being commonly viewed as matters of engineering rather than physics. For example, in the field of heat it was thought that industrial physics should concern itself with such matters as the rate of heat flow, exact determination of high temperature, or the amount of radiation losses, rather than with the design of furnaces or their method of operation to secure the highest possible temperatures.

In the electrical field there is no real line of demarcation possible between industrial physics and electrical engineering. However, most of the pioneer work involving fundamental propositions and phenomena as applied to the problems in industry is usually classed as physics, while the same sort of thing, when it has been more developed and more fully applied to matters of regular operation or manufacture, is usually classed as electrical engineering.

Upon the mechanics of the pure physicist is built the whole great structure of mechanical engineering, while the industrial physicist occupies the region between the two, concerning himself with such matters as the principles of aero-dynamics, hydro-dynamics, elasticity, photo-elasticity, hardness, friction, and viscous flow.

The attention of the public, which was called to matters of physics in war time, and the great popular recognition of development in physics as a science because of the amount of information gained in such matters as radio, television, talking moving pictures and airplanes, and the new laws and principles which underly them, has done much to make industry regard physics as a part of its stock-in-trade. It is not so much that the physicist has decided to leave the shelter of his heretofore cloistered existence and come into industry, as that the makers of films, airplanes, and firebricks have discovered that they need physicists if they are to make films which are pleasing to eye and ear, and airplanes in which the utmost limits of speed and safety are attained, and furnaces in which the hottest fires may be kept up for the longest possible time.

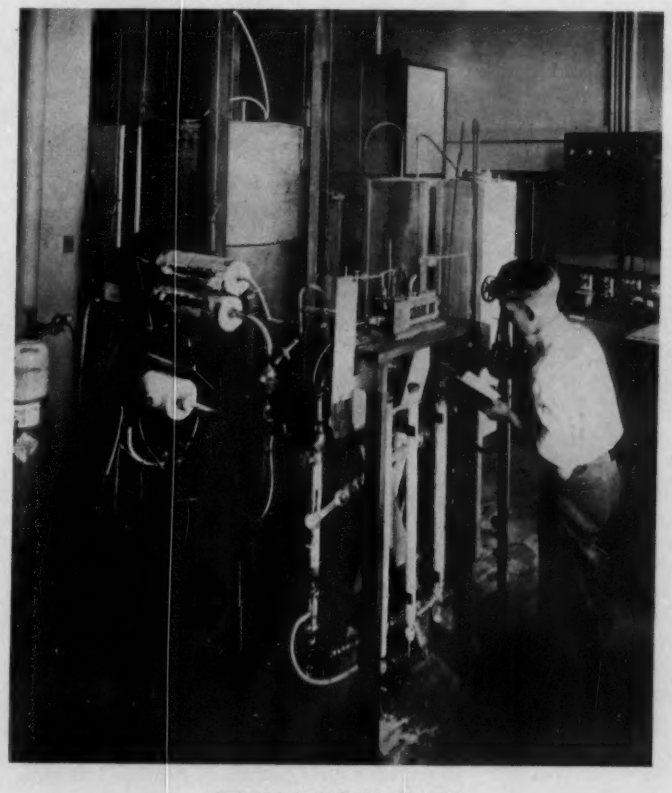
The number of industries which have felt the need of men trained in physics is considerable, but until within a short time physical problems arising in industry were likely to be turned over to one or two members of the regular industrial staff of the old days, the works chemist or the engineer. It was only infrequently that the problem received much careful physical treatment at their hands. Usually neither time nor equipment was available even though the necessary knowledge and experience was at hand. The research laboratory was not a common attachment to an industrial project, and as far as physics was concerned, it simply "wasn't done." As the number of important physical problems increased and as there began to be here and there new and very prosperous industries which concerned themselves with such things as optical systems, vacuum tubes, radio transmitters, telephones and ultra-violet lamps, the call for physicists in industry became loud and constant.

Let us look for a moment at several typical industries which have been in existence for a long time. Perhaps no existing industry goes back much further than the art of the potter. Not only was this industry one of the oldest, but one of the slowest, to develop. In many places bricks and jugs are made very much today as they were made three thousand years ago, but in a modern plant the manufacture of pottery or porcelain insulators, men are needed for development work who are able to discuss the tremendously complicated structure of burned clay, to know by actual experience the findings of the microscope and the X-ray spectrograph, to determine the porosity, density, dielectric strength and fusion-point of earthy materials, and to conduct researches upon the effects of repeated thermal and electrical stress. This may appear to be a considerable undertaking for a brickmaker, but it would appear to be a most interesting field for an energetic, imaginative young physicist even in such an old and simple industry as that of the potter. In all probability it takes fully as much real physical information and sound scientific reasoning to enable one to plan and construct an efficient abrasive wheel for a particular kind of cutting as to design a modern vacuum tube. This is the sort of thing which the modern industrial physicist in the ceramic industry is likely to be concerned with.

The electrical industry has developed rapidly as a direct offshoot of physics, and has always carried along with it men working on purely electrical problems. The industrial worker in the electrical field, therefore, is likely to find himself in a rather different atmosphere from his fellow who works in the older branches of applied science. The laboratories of the great electrical and telephone companies have always had numbers of men working on purely physical problems. Frequently these have no apparent industrial applications when begun, but experience has shown that in almost every instance information as to physical principles, properties of matter, and phenomena becomes, sooner or later, of industrial importance. In these great laboratories we find men working on the most advanced theoretical problems relating to the known theories of physics. Nothing in acoustics or optics, or the electro-mechanical theories, or quantum mechanics, or the nature of matter, or energy, is neglected by the industrial research worker if, in his meditations, he comes upon definite instances of lack of experimental data, or of incomplete reasoning. All this, mind you, is the everyday work of the physicist, not in the university but in industry.

There was a time when industry guarded rather jealously the secrets which its research workers discovered, feeling that the only return for the great expense involved must lie in exclusive rights to use such information as resulted. For years, therefore, the physicists in an industrial laboratory were under a handicap as compared with their co-workers in the schools and universities, in that they could not print the results of their researches and receive such credit as might properly attend publication. All this is now changed, and while for one or another reason there might be some delay in publication, the workers from industry who present publications at the meetings of the great scientific societies are perhaps quite as numerous as those from the colleges and industries.

It was with a partial realization of conditions such as have just been outlined that the course in physics at Technology was revised in 1914, and the Department has just now completed a second revision in the light of the experiences of the last dozen years. There have been numbers of minor changes from year to year. The schedule for the first year is, of course, substantially like that of all the other courses. The schedule for the second year differs from the old schedule merely in providing means of strengthening the instruction in mathematics to make it more applicable to the work of the physicist and to prepare the groundwork for more theoretical physics, if desired, in the fourth and graduate years. In the third and fourth year the work is so arranged that a man may be permitted, particularly toward the end of his course, to emphasize such portion of the work in physics as interests him most, and at the same time requires a reasonable working knowledge of the other branches of physics. This arrangement is made so that if the young man finds himself particularly interested, for instance, in optics or electricity, thinking perhaps that he may find his life work in the field of television or radio, he may have much more time to specialize in the particular work in which he is interested than has heretofore been the case. A very considerable portion of the fourth year is made elective, to permit of a rather intensive specializing in subjects of one general type. Since experience has shown that the larger part of the students taking physics desire to spend more than four years at the Institute, further attention is now being given to the establishment of additional graduate courses in the several branches of physics.



ARGON PURIFICATION

The most advanced theoretical problems in physics are solved in the great commercial laboratories of which this is a typical example.

The one distinct advantage which is believed to result from the setting up of the new schedule is that it will allow students who are interested in theoretical and mathematical physics to devote their attention almost exclusively to work of that sort in their fourth year, in preparation for graduate work. It seems perfectly clear that any student who elects to take work in theoretical physics will contemplate continuing as a graduate student in that field. Arrangements are being made to increase the range and scope of the graduate work in theoretical subjects relating to physics. There are at present available for graduates in the Department of Physics several scholarships and fellowships, notably the Malcolm Cotton Brown fellowship, and the Swope and Proctor scholarships. Besides these special awards there are the regular graduate fellowships and scholarships available for graduates of all courses.

Recently, as a result of suggestions from the industry itself, the Department of Physics has been endeavoring to arrange for suitable training of physicists in connection with the ceramic industry, and to that end an elective course is to be offered in the fourth year, followed by graduate work in theoretical and applied ceramics.

Frequently inquiry comes to the Department as to the financial prospects of men who go into the field of industrial physics rather than engineering. The profession, as such, has not been established long enough to furnish any great array of statistics, but such information as is at hand concerning the remuneration which is received by men who devote their time to physics in industry indicates that they are quite as satisfactorily placed as their fellows in the engineering professions, and decidedly at an advantage when compared with those who are practising physics, either in a teaching or research capacity, in connection with the schools and colleges. In industrial physics, as in all other scientific work which concerns itself largely with research, the men soon divide themselves into two groups; those who continue only in their scientific or engineering work, and those who combine with such work some added admin-

(*Continued on page 152*)

Engineering Employment in South America

Valuable information for the graduating engineer who contemplates a career in a foreign country

By An M. I. T. Alumnus

WHEN considering employment on engineering work in South America, the young engineer should keep in mind first of all that business is the primary cause which is responsible for engineering work; that is to say, that engineering works are required, financed, and built because there are business enterprises which directly or indirectly require them. At first it may seem that government works involving engineering are an exception to this, but a closer analysis shows that unless there is business being done from which a government can derive revenue by taxation, the government itself will not be able to justify expenditures for engineering works. It used to be said that trade follows the flag, but it can be said with even more assurance that engineering follows business.

It is evident from this that in the United States, where there is great activity of business in all lines of effort, there is a wider range of engineering work — both in variety and magnitude — than exists in the Southern Continent with its small population and, as yet, comparatively undeveloped resources. If the young engineer, then, is looking for breadth of experience primarily, the chances are that he will find it here in his own country in greater measure than in South America.

There are, however, other aspects of the matter. Perhaps the graduating engineer has made up his mind that he wishes to get a taste of foreign work with the consequent wider view of affairs that it entails. He can embark in a spirit of adventure, taking a chance on getting a job as he travels around. This is almost pure speculation and is generally very unsatisfactory because, unless a man has some capital to work on, he may be squeezed into accepting a job without experience or future simply because he needs the money. It is far better for him, unless he is perfectly willing to take this chance, to endeavor to make a connection here in the United States with some American firm which is doing business in these countries. If he is successful in making such a connection, he will be classified as what is generally called a "head office" man, which means that he is entitled to a vacation in the United States every three or four years with his travelling expenses paid. Even if he happens to be so fortunate as to be taken on while in the foreign field by one of these same organizations, unless he has made arrangements before leaving the United States he will generally be classified as a local employee and entitled only to the same privileges as regards vacations to which they are entitled.

The matter of languages is important. With one exception, a knowledge of Spanish is vital in all of the Latin-American Republics. That one, of course, is Brazil, where the language is Portuguese. While it is not generally essential to have full command of the foreign language before going to one of these countries, some acquaintance with it is very desirable, as otherwise it cuts a man off from one of the principal reasons for going abroad, namely, the broadening influence that comes with understanding a foreign nation by speaking the language. There are, to be sure, concentrated groups of Americans working in certain enterprises in South America and living in colonies without much association with outside influences, where English is spoken almost entirely. Such locations, however, do not supply much in the way of a broad experience and the young engineer generally might as well remain in the United States.

At the author's request, The Tech Engineering News *is presenting this article anonymously. We may say, however, that both as an engineer and as a business man, he is well qualified to write on the subject of engineering opportunity in the southern continent. Having spent considerable time in South America the substance of his paper has been gathered from personal observation. Every young engineer facing the problem of what to do after graduation will find in this article the frank opinion of a man of experience concerning this field of engineering.*

The young engineer will do well to look over the field in these different countries. Beginning at the north with the Republic of Colombia, there is a great deal of engineering work being done by some of the great American corporations such as those interested in mining, oil, and fruit. This also applies in a lesser degree to Venezuela. The field in the small country of Ecuador is, naturally, very limited. In Peru, American engineers have made great contributions. A great deal of construction work has been done by American firms, and there are a considerable number of mining interests in the hands of Americans. Practically all the railways, however, are controlled by British interests. In Chile, the possibilities for the young American engineer would be largely in the field of mining. This would also be the case in Bolivia. In Argentina, the country is for the most part very flat, and there are very few engineering problems of importance in the way of bridge and railway construction. Here, also, the railways are largely in the hands of British interests. There are, however, many successful American enterprises in Argentina, among which may be mentioned the packing houses and the oil companies. Of late years certain American construction firms have done excellent work in the building of highways. The transportation system in Brazil is largely in the hands of foreign interests, and while the stupendous size of the country and its diversity of topography make engineering developments in the way of roads and bridges important for the future development of the Republic, the sparse population and the problem of financing such work make progress slow. Paraguay is, at present, comparatively unimportant from the point of view of the young engineer.

A thing which should be kept in mind by the young engineer in laying out his future is that a background of sound engineering training and experience forms a valuable asset in many lines of business. This is true at home, and perhaps even more so abroad. The branch executives in the offices of American organizations abroad are very frequently men with engineering training who have made themselves valuable by supplementing their technical qualifications with a knowledge of accounting and general business methods. It is a strong combination, and the compensation that goes with it is apt to be better than that paid for purely technical engineering services. It is well to remember, too, that whereas the demand for engineering brains fluctuates with the

(*Continued on page 162*)

Airplane Engineering

Some thoughts of an eminent authority on the design and construction of the modern airplane

By ALFRED A. GASSNER
In charge of Engineering
Fokker Aircraft Corporation

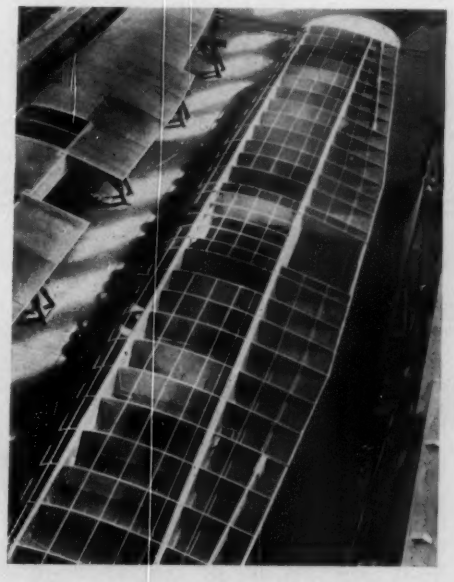
AIRPLANE engineering is a combination of science, art, and experience. The consideration of only two of these characteristics without the third could not permit the creation of a good airworthy and well performing airplane.

We might even go as far as to state that it is impossible to design and build a good airplane by solely following scientific methods without copying existing types, *i.e.*, by only calculating correctly the aerodynamic and structural parts of the ship. In other words, the correct calculation of the aerodynamic and structural members of the ship is not sufficient unless backed by previous experience. There are hundreds of little details to be considered which all work together in making a good ship; little details in design and in the manufacturing process, many of which seem insignificant, but which in the end mean the success or failure of a good design.

Each modern airplane, for whatever purpose designed, is the result of a compromise. We cannot design "the perfect airplane." Each ship manufactured has certain advantages and shortcomings, in comparison with other planes designed for the same general requirements. As there are about fifty different purposes for which a plane can be designed, and as in each of these classes the one or the other point is more important, it is very hard to compare two ships even in the same category. To make this compromise in the most efficient way, to win much on one side without losing any or little on the other, is the first hard task confronting the designer. This characteristic of modern airplane designing is one of the reasons why we cannot build revolutionary new types with good hope for success and why we have to develop a new type from a previous one.

We cannot design a plane which will be record breaking at high speed, carry at the same time a high load per horse power, have a good climb and slow landing speed and still be cheap to build and low on maintenance. I might add that this is a fundamental law of transportation ever since man has used it. The world record for high speed now stands at 319 miles per hour. It will be very difficult to increase this figure and still have a reasonable amount of safety for take-off and landing. It is interesting to note that this record was made with a ship equipped with floats, as with a high landing speed which is at present the necessary evil of high speed planes, it is far less dangerous to land on smooth water because of the larger surface generally found than on any landing field.

An entirely new requirement will be introduced very soon for commercial airplanes — high speed at high altitudes. This will necessitate some revision of the aerodynamic part of the ship as far as wing areas and wing sections are concerned, and also the universal use of superchargers for the engines.



CANTILEVER WING CONSTRUCTION

The development of this wing, which combines strength, lightness, and aerodynamic efficiency to the highest degree, represents a great step in aeronautic advance.

Army and Navy ships are generally designed to given specifications and the desired qualities have been predetermined by Government experts who have a great amount of exact and reliable data available from previous ships of the same general class. They can therefore judge the requirements, desirability, and possible improvements of new models.

This problem is by far more complicated in the commercial field. Airplane manufacturing concerns or their designing engineers who are building commercial ships of a certain type have reliable data of their own ships available only. Trade paper and advertising figures on performances, weights, etc., of competitive ships are often given with optimistic values, not necessarily intentional, but sometimes because those figures come from test flights of experimental planes, and in the actual production job additional weight had to go in the structural or finishing parts of the ship, and area of wing or tail surfaces had to be changed for one reason or the other.

Operators and pilots in the commercial field are not enthusiastic on the idea of compromise on performance characteristics; they also differ widely in their opinions as to the necessary qualities and desirability of their ships, and their ideal is, of course, a ship in which everything which can be termed performance is either a maximum or a minimum. In the maximum category would be included weight carried per horse power, cruising speed, cruising range, climb, ceiling, stability, ease of maintenance. In the minimum category we would have landing speed, fuel consumption, take-off speed, landing run, and, of course, as one of the most vital factors, low cost.

The engineering departments in our great automobile plants are luckier in this respect. Cars of all makes and types are available for comparative tests and the effect of changes can be studied at present with more leisure than in the airplane industry.

We see, therefore, that the airplane engineer has to cope with a situation which is absolutely peculiar to the airplane business, and which cannot be found, to any comparative extent, in any other business of manufacturing transportation vehicles, be it automobiles, busses, railroad equipment or steamships. Today, science alone cannot show us the way out of this labyrinth. Experience must decide which of all these qualities are the most necessary ones, and from which we can make smaller or larger sacrifices. If increasingly reliable data and statistics are to be available, in the future, this problem will be narrowed down more and more, and gradually the whole industry will be in a more stable state of affairs, *i.e.*, from the purely technical viewpoint.

The automobile industry has today reached this state, and the new models are designed two years ahead of actual production in quantities. In the airplane business we have still to build ships from drawings not older than a few months, and this can be done with success only when the builder has a

(*Continued on page 154*)

Beams in Bending

Photo-elastic experiments which illustrate important principles of applied mechanics

By THOMAS H. FROST '21
Assistant Professor of Physics
Massachusetts Institute of Technology
and
ROBERT S. HATCHER, Grad.
Lieutenant (Junior Grade) CC. U. S. N.

THE photo-elastic method has been taken up in great detail and in numerous journals* by previous authors. It is felt that a complete understanding of the various experimental results given below can be obtained from a brief summary, coupled with a few definitions as follows:

The photo-elastic method is an optical experimental method, based upon the temporary double refraction of transparent materials when stressed, for the determination of stress distributions. When a transparent model of a structure is placed in a beam of polarized light, stressed and analyzed, the directions as well as the magnitudes of the two principal stresses can be determined at every point.

When plane polarized light is employed, all points at which the directions of the two stresses coincide with the principal planes of the prisms used for polarizing and analyzing, the image remains dark. The loci of these points are called isoclinic lines. From these isoclinic lines, the lines of principal stress, which are tangent at every point to one of the principal stress, are graphically determined. Any region of zero stress naturally remains dark under all conditions.

When circularly polarized light is used, the isoclinic lines are suppressed, and the color effects due to the double refraction can be evaluated by a compensation method, in terms of pounds per square inch. Under good working conditions the error in such measurements can be kept below three per cent.

In the present paper the results of a few simple experiments on beams under bending are presented and discussed for the purpose of pointing out to the undergraduate student the approximations which are made in applying the beam theory and impressing upon him the necessity of complying with the limitations so often pointed out in the classroom.

No single subject falling under the theory of elasticity and the strength of materials possesses a wider historical background or field of importance than the beam theory. So long as men have built shelters to protect themselves from the elements, just so long have they concerned themselves by intuition, by trial, by experience, or by more refined, if sometimes less exact methods, with the strength of beams, the most important members of their structures.

The most brilliant names in the history of mathematics and physics have been linked with these later and more refined methods. Half a century before the discovery of Hooke's Law, Galileo speculated on the forces which support a built-in stone cantilever beam. Later, Mariotte, Coulomb, the Bernoullis, Euler, Poisson, Saint Venant, Rankine and many others advanced the theory in line with the progress of the general theory of elasticity. These results have received the test of practice in so many ways, the formulae have been so simplified and codified, that the elements of the beam theory form almost the A B C's of the engineer. So simple and practical are the applications of a theory which required centuries of growth that every effort is made to extend them to cases which differ more and more widely from those which the theory accurately portrays.

There is a saying that familiarity breeds contempt, and so, like a little knowledge, it may become a dangerous thing. In this case there is the danger that the engineer may come to look upon the easily attained results of his beam calculations as exact in themselves, forgetting the assumptions and approximations on which they are finally based. Hence a very brief résumé of the usual ones may not be out of place.

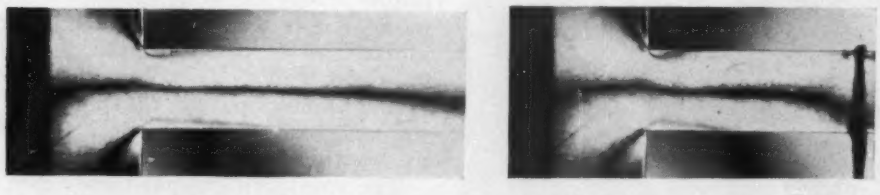
The ordinary theory of bending rests on the following assumptions:

(1) Plane cross sections remain plane and normal to the longitudinal fibers after bending.

(2) The material obeys Hooke's Law; that is, the stress intensity is proportional to the strain throughout the beam.

(3) Every longitudinal fiber is free to extend or contract under stress as if separate from the other fibers, and the ratio of stress intensity to strain is the same in every fiber.

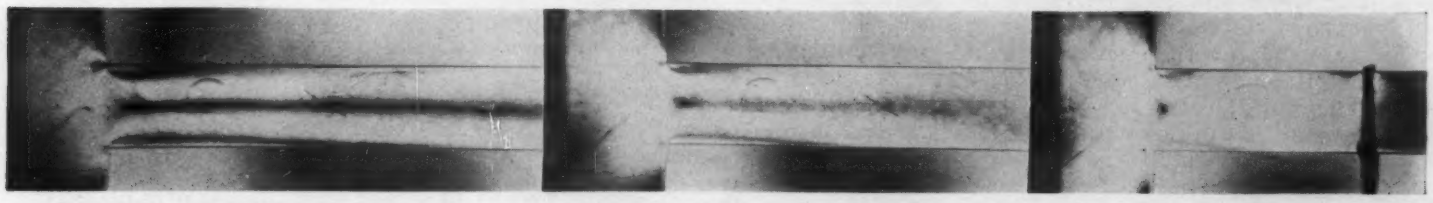
Above and beyond these is a still more vital proposition which must be relied on, and without which there could be no satisfactory beam theory. According to this theorem, known as Saint Venant's principle, the stresses at all points in a stressed body, which are not too near a point of application of an external force, depend not on the exact manner of application of the loads and reactions, but only on the



A B

FIG. 2. DEMONSTRATIONS OF SAINT VENANT'S PRINCIPLE
The neutral axis ceases to pass through the center near the point of application of the load.

*TECH ENGINEERING NEWS, May 1922.



A B C

FIG. 1. TESTS ON THE RATIO OF DEPTH TO LENGTH OF A CANTILEVER BEAM
As the beam is shortened from ten to five, and two and a half inches, the neutral axis disappears.

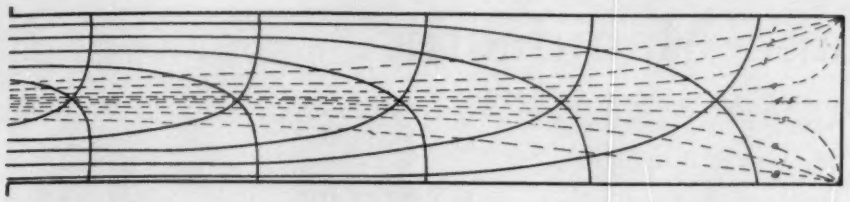


FIG. 5. THEORETICAL STRESS DISTRIBUTION IN CANTILEVER BEAM
These lines were determined by the method of Volume II, Fuller and Johnston's "Applied Mechanics." They may be compared with the actual experimental results shown in Fig. 4.

statical resultants of these force systems. Starting from this principle we may develop a stress system which satisfies the following requirements:

(*a*) Each particle is separately in equilibrium.

(*b*) The strains and deformations of the stressed body are those which could possibly occur without loss of continuity of the material.

(*c*) The stresses at the boundaries of the body reduce to systems which are statically equivalent to the applied forces.

Having done so we may presume from Saint Venant's principle that we have accurately portrayed the stress conditions at all points except those very near to the places of application of the loads.

The beam theory as given in modern textbooks is developed according to a method invented by Rankine, based on the assumptions previously noted; it has the advantage of great simplicity, but it is not perfectly in accordance with the results of the more exact methods of the general theory of elasticity. Suffice it to say for the present that the common theory is most nearly exact when the loads are applied in the form of couples or concentrated weights, rather than distributed along the length of the beam; when the depth of the beam is small compared with the length; and when the breadth is small compared with the depth. This theory leads to the following results:

A line of longitudinal fibers designated as the neutral axis suffers no extension; a plane imagined to be passed through the beam normal to the neutral axis is acted on by normal stresses and shear stresses, which vary across the section in such manner that the normal stress is a linear function of distance from the neutral axis while a shear stress diagram for a rectangular section has the form of a parabola; these stresses are so adjusted in magnitude that they hold in equilibrium all the external forces on either side of the section.

Fig. 1 shows the effect of the ratio of depth to length on the neutral axis of a cantilever beam. We have here a 1 x ¼ x 12-inch cantilever beam with concentrated loads at 10, 5 and 2½ inches from the root, in (*A*), (*B*) and (*C*) respectively; the loads were so adjusted as to produce the same bending moment at the support in each case, 50 inch-pounds. These photographs were taken under circularly polarized light, so that the shadow effects are independent of the stress directions. In 1(*A*) we see very clearly the dark central line corresponding to the neutral axis or line of pure shear; in 1(*B*) the neutral axis has become somewhat fainter; and in 1(*C*) where the loaded length has been reduced to two and one-half times the depth, it has vanished altogether.

According to the common theory, the median line through the centroids of the sections is also supposed to be the locus of points where the principal stresses are at angles of 45 degrees to the vertical. The photographs of Fig. 2 were taken in plane polarized light with the polarizer and analyzer set at those angles, and show the actual positions of the loci in two cases. In Fig. 2 (*A*) with the load at 5 inches from the root and in 2 (*B*) at 2½ inches the correspondence is nearly exact to within a distance from the load less than the breadth of the beam. The validity of Saint Venant's principle is here well demonstrated. The neutral axis should be rigidly defined as the line of no

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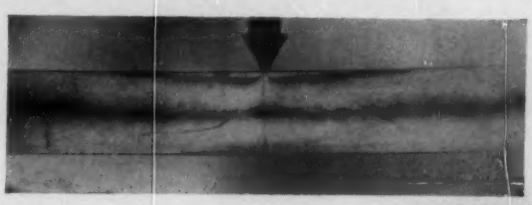
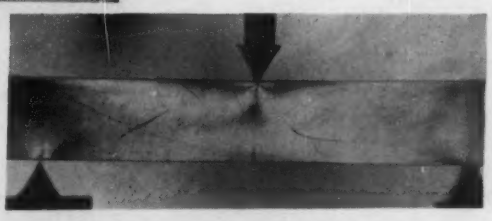


(*Left*) Ten inches long, supported at the ends, loaded at the center.



(*Right*) Five-inch beam, concentrated load. Note the disappearance of the neutral axis.

FIG. 6. SIMPLE BEAMS IN CIRCULARLY POLARIZED LIGHT

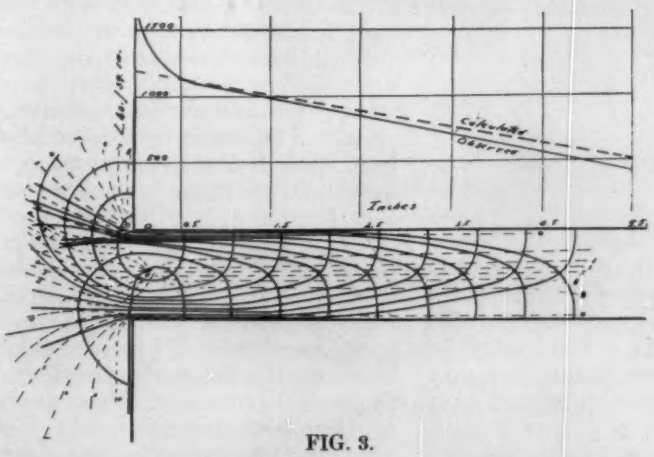


FIG. 3.
TEN-INCH CANTILEVER WITH FIVE-POUND LOAD

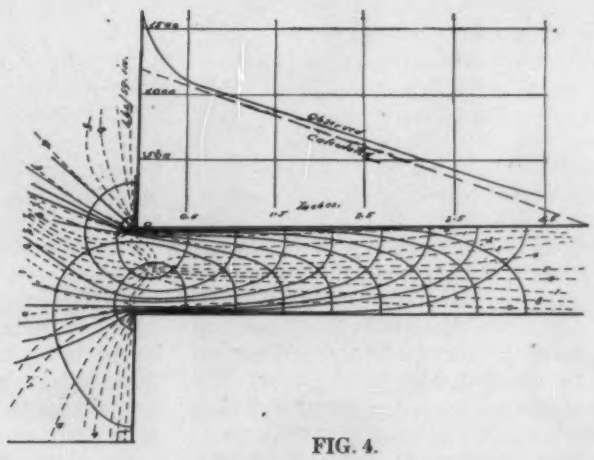


FIG. 4.
FIVE-INCH CANTILEVER WITH TEN-POUND LOAD

In each case, the load is concentrated at the end. Isoclinic lines are dotted, lines of principle stress are full lines. The calculated and observed values of the stress in the most strained fiber on the tension side are shown.

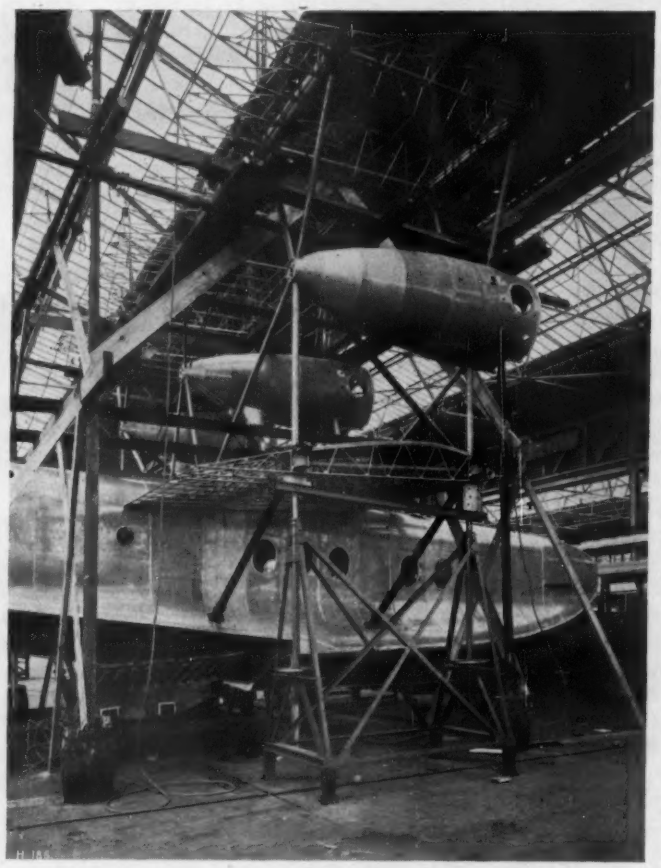
Airplane Manufacture

Increasing production brings modern methods to the aeronautical industry

By ALFRED B. BERGHELL '31

THE airplane in its development has often been compared to the automobile. In the early days of the growth of the motor car the methods used in constructing it were crude and largely the result of trial and error, and the airplane has had to pass through a similar stage. The airplane has had, however, a great many advantages, which are the direct result of this previous pioneering work, a number of which have been applied with some changes to airplane manufacture. Today, with the increasing production of airplanes, greater use is being made of the experience gained in the automobile industry.

The first airplanes to be constructed and to fly were often largely the work of one or two men who, with little assistance, designed, constructed, tested, and flew their handiwork. They were in turn engineer, manufacturer, mechanic, and pilot. One plane only was being built, and upon it the energy of the builders was concentrated. The plane was not being built for profit but for experimental purposes. Time and cost were not large factors, for the plane was being built to prove or disprove the theories of the designers. As a few others besides the builders themselves learned to fly, a very slight demand arose for airplanes to fly in, and this demand was met by the construction of a few machines for sale. The method of manufacture was the same, however, each airplane differing from its predecessor, as new principles were discovered and applied and additional experiments were made.



THE "CALCUTTA" UNDER CONSTRUCTION

This is one of the latest type English flying boats. Note the unusual design of the motor supports and the metal tube construction of the wings.

In the past, it has been difficult to manufacture airplanes at low cost and with the greatest efficieney because of the constant changes being made in design, and the small number of planes being built. Today this condition is rapidly changing. With the increasing demand for airplanes which is manifesting itself, the aeronautical industry is reaching the stage where quantity production can be economically used. When the manufacturer has a large and constant market for his products, standardization can be attained and cost of production brought down to the lowest possible level. With standardization it is possible to employ special machinery and to make up expensive tools and jigs for the better, cheaper and faster fabrication of parts.

Much still remains to be done along this line. A great deal can be saved in time and money by greater simplification of parts, and it has often been found practical to greatly reduce the number of parts used in the construction of airplanes by using the same part in different places instead of two different parts which are only slightly unlike. If standardization is kept constantly before the designer, it will be found possible in many cases, if more than one model of ship is being manufactured, to design the different models so that a large number of small parts used are interchangeable for the different models. This is being done to some extent at the present time, but not nearly to as great an extent as is possible.

Anything which tends to simplify speeds up production and cuts costs, therefore simplification should always be striven for. Airplane fittings are constantly being simplified as better methods of fabrication are being found. Fittings which were formerly made by hand, because only one or two were needed per ship and it did not pay to make the tools necessary or to set up the machines, are now being made by machine in an increasing proportion. Machine operations on fittings are themselves being improved. Tools and machines have been developed to do in one operation things which formerly required several. The tendency is towards standardization as far as possible, but because of the constant improvements still being made, standardization cannot be absolute. That which has been accomplished has already lowered the cost of airplanes by a very considerable amount.

With the increase in production, better manufacturing facilities became necessary. Some of the companies now manufacturing airplanes have grown from small organizations to large producers. With the growth of production from one or two ships a year at the start to several hundred each year at the present time, there naturally has been quite a change in the factory. The small shop located in any available building, has given way to the factory especially designed and built for the production of airplanes, and the mechanics who, few in number, worked in turn on all parts of the ship in its construction, have now, in their augmented numbers, been divided into groups, each of which specializes on some particular type of work. These groups have also been subdivided, so that the men in them generally specialize on a few specific parts of the ship. The result is greater production with better workmanship, and lower labor cost per unit of time.

In the line type of factory, the bare fuselage starts at one end and the finished plane comes off the assembly floor at the other. Small parts are added as it moves through the factory, together with such sub assemblies as landing gear, tail surfaces, wings, and the motor, or motors. These are made up by feeder departments located along the line the plane takes, or purchased, as is often the case with motors. Production is so timed that the parts needed are ready for the plane as it

THE ASSEMBLY LINE

An illustration of the increasing trend toward mass production in the airplane industry.

progresses through the factory. The line type of factory, which is similar to the automobile factory, has been adapted by a good many airplane manufacturers.

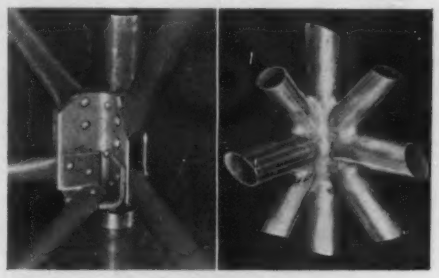
Control of parts in the process of fabrication so that they will arrive when needed on the assembly line is a necessity, if valuable time is not to be wasted by those dependent on parts. Everything must be coördinated in such a manner that the plane proceeds smoothly from start to finish, and naturally, one of the most important things to have if this is to be accomplished is a well-trained, loyal personnel. This requires good management at the top, and contented, fairly paid workers in the shops. Although we live in a machine age, the personal element enters into the control of the machinery so that the worker who knows that he is being treated fairly and feels that he is really of some importance, no matter how small his job, does a great deal towards making for the final success of the organization as a whole. The organization is nothing more than the total expression of its component parts.

Formerly, most of the airplanes manufactured were sold to the government for army and navy work, but today commercial interests absorb an increasing amount of the output. These want low initial and upkeep costs which are essential if profits are to be made. When a new type of airplane is to be manufactured, the cost of engineering alone on the first plane made is sometimes as high, or higher, than the direct labor cost. The total cost, made up of engineering, direct labor, overhead and indirect labor, and materials will therefore be great. However, if the new model is tested and proves successful, with perhaps a few changes, and is then standardized and quite a number are manufactured, the engineering cost can be distributed over that number and becomes proportionately low.

The engineering required on the plane after it has been put into production is negligible. The direct labor is reduced due to standardization, and the time of manufacture per plane is also greatly reduced. The greater the number being manufactured, the more the cost can be cut and the faster the planes can be manufactured, with proper equipment. Planes of different types and models vary over wide limits as to cost, so that the number of planes being produced by one factory cannot fairly be compared to another to determine the relative business done. Frequently, too, a company may be doing a large amount of experimental work for which they are receiving no present return, but which has great potential possibilities.

The use of metal in airplane manufacture is increasing. It is stronger and more uniform, and for these reasons safe loads can be more easily estimated. Moreover, it does not deteriorate as quickly as wooden construction, there is less danger from fire, and the upkeep is less. The two types of metal most widely used are steel and various aluminum alloys, of which duralumin or dural is the most common. Dural is lighter than steel, but has not the same strength and cannot be welded successfully at the present time.

Due to its light weight, dural tubing is extensively used by many manufacturers. The annealed tubing can be bent to shape and then heat-treated to harden it, and riveted to joining parts to make the required assembly. Dural tubing fuselages are used in some ships, with aluminum alloy cast-



FUSELAGE JOINTS

Welded and riveted metal tube construction in modern airplane manufacture has almost entirely superseded the wood and wire combination.

ings at the joints, while others use machined dural bar stock to join the different tubes. Wing ribs and wing beams or spars are often made of dural tubing. The use of tubing requires a great amount of riveting for the joining together of the different parts. Sometimes the number of parts required can be reduced by the use of sheet dural, formed with the use of dies to the shape required, from one piece of sheet metal. This is being done to a large extent with ribs, and has also been done with spars. In order

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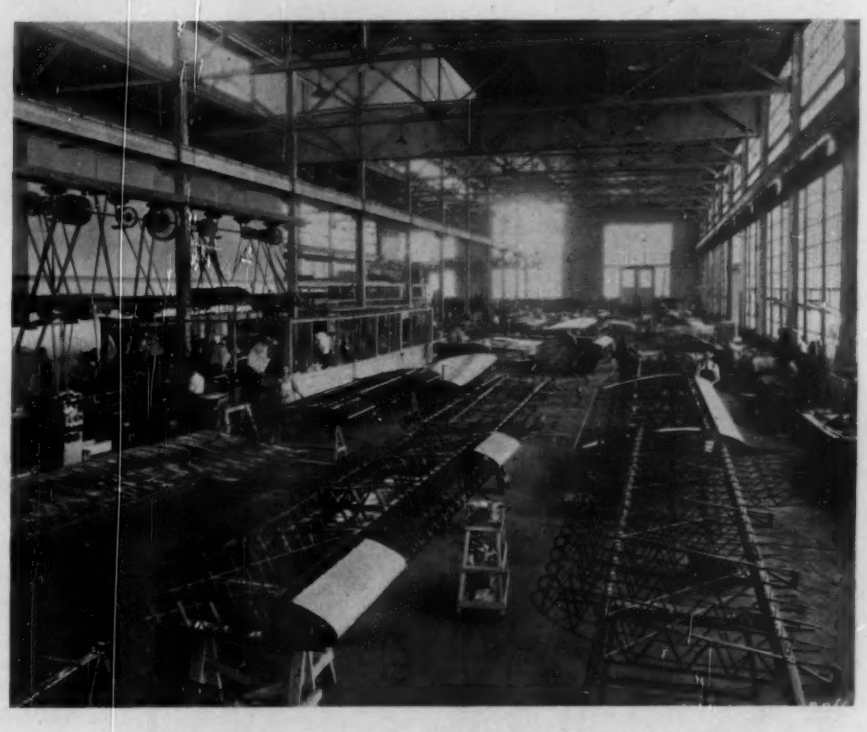


WING DEPARTMENT AT THE SIKORSKY FACTORY

All parts of these all-metal wings are bolted and riveted, no welded joints being used.

FIG. 1

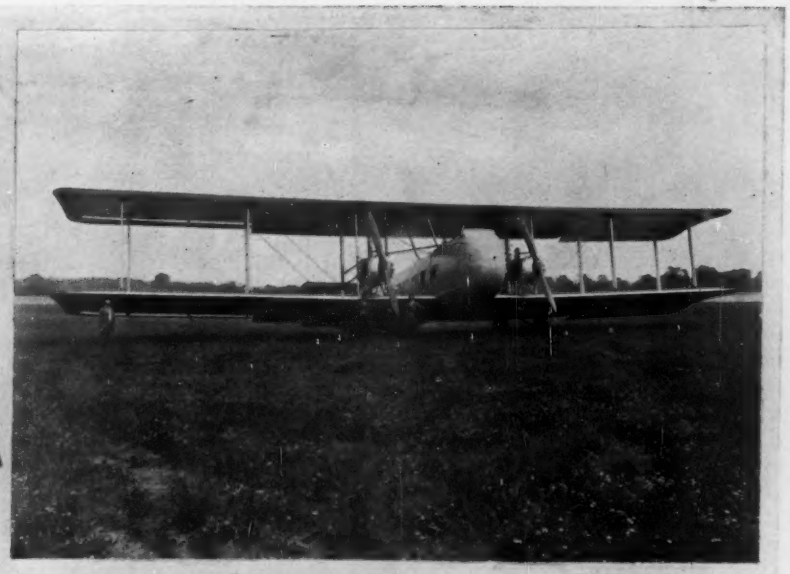


FIG. 2

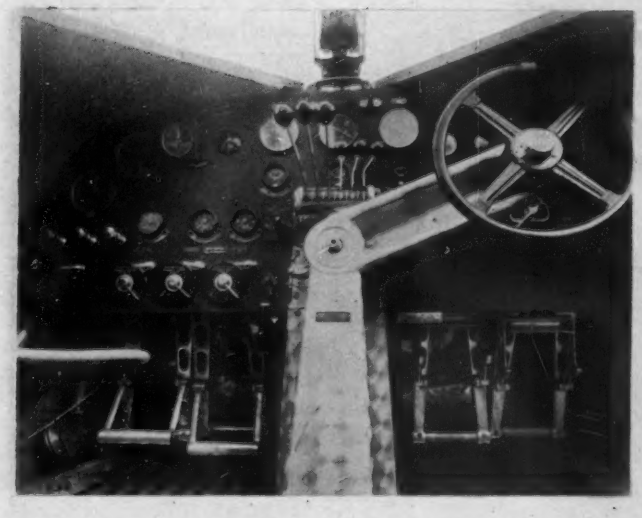


FIG. 3

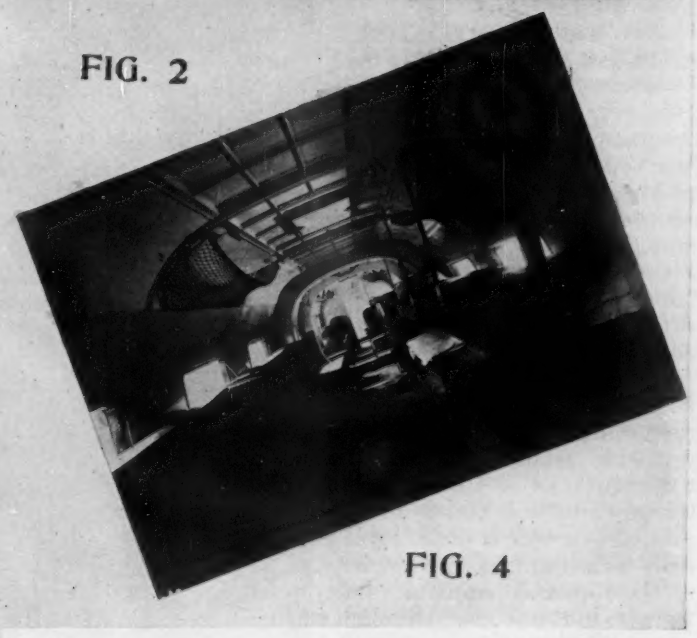


FIG. 4

FIG. 5

Fig. 1. The Boeing twelve passenger transport airplane. The power plant consists of three Pratt and Whitney "Hornet" engines of 500 h.p. each. Passenger comfort is provided for, as evidenced by the adjustable seats, individual seat-lights, unobstructed windows, and hot and cold running water as cabin equipment. The total weight of the plane loaded is 16,500 pounds; the pay load is 4,650 pounds. The fuselage is of welded steel and bolted dural tubing; the wing ribs are of dural.

Fig. 2. The Vicker's "Victoria," British troop carrier, recently equipped with British Jupiter IX geared motors.

Fig. 3. Instrument board and flying controls of a Fokker F-10 Trimotor Transport. Control may be shifted from one pilot to another by moving the wheel on the control column from the right to the left. Dual rudder control is provided.

Fig. 4. Interior of the Farman F-180 Transport showing the large size of the cabin, and the arrangement of the seats in the left foreground, which may be converted into berths for the night as shown on the right. Passengers may make night journeys with all the comforts of a Pullman car in this airplane.

FIG. 6

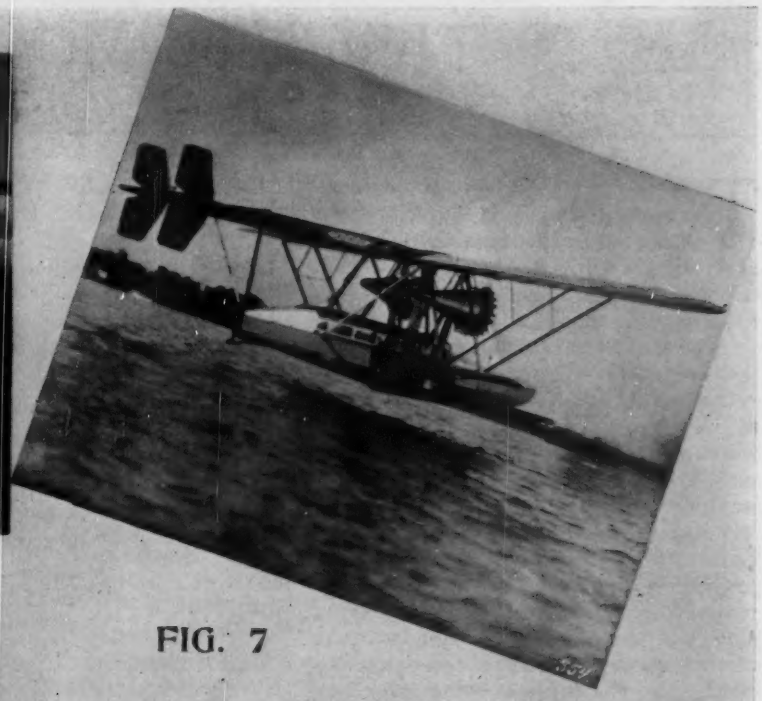


FIG. 7

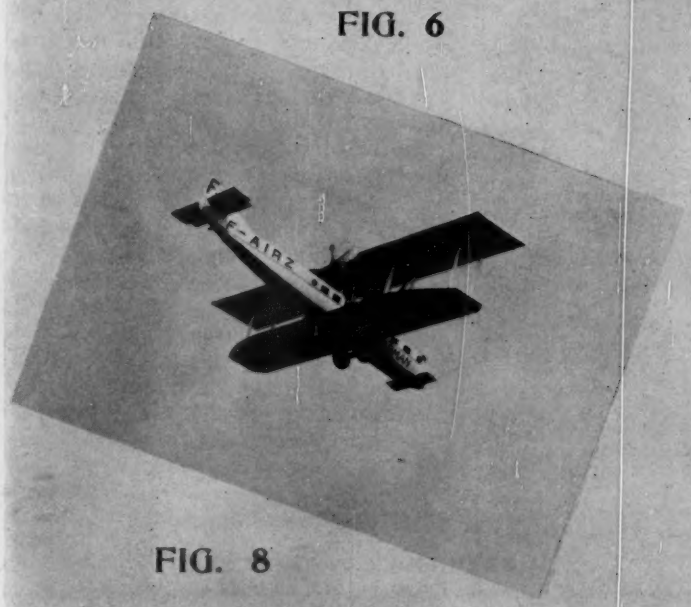


FIG. 8

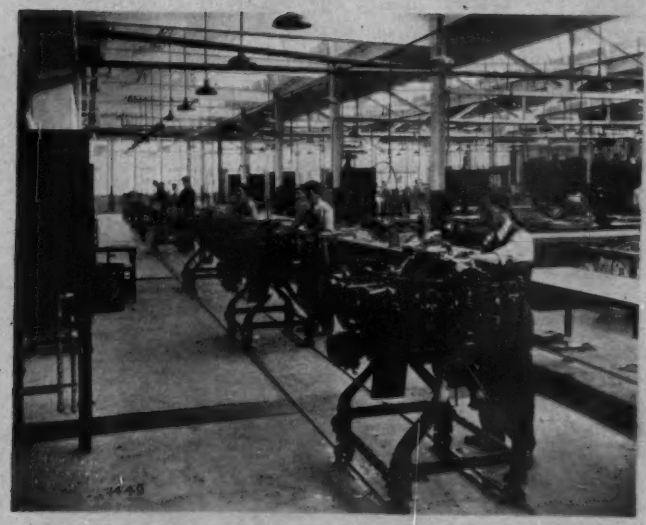


FIG. 9

FIG. 10

Fig. 5. View of the boat hull department of the Sikorsky Aviation Corporation. In the lower right of the picture may be seen the tops of the hulls, with openings for the windows. These hulls will become a part of the S-38 amphibians.

Fig. 6. Interior view of a Standard S-38 Sikorsky amphibian. Note the comfortable cabin and the large windows unobstructed by structural members.

Fig. 7. Sikorsky S-38 amphibian taking off from the water. The wings are set high above the surface of the water, and the hull is made of metal, so that the ship is seaworthy in rough water.

Fig. 8. Farman Commercial Transport F-180 equipped with two Farman 12 WE. motors in tandem. This airplane has seats for twenty-five passengers in day travel, or berths for twelve for night journeys. It is manufactured in France and used on European airlines.

Fig. 9. The assembly line of the Wright "Whirlwind Engines." This view is indicative of the methods of mass productions.

Fig. 10. Building plywood wings and fuselages at the Lockheed Aircraft Company. Plywood construction combines light weight with strength, flexibility, and low maintenance costs.

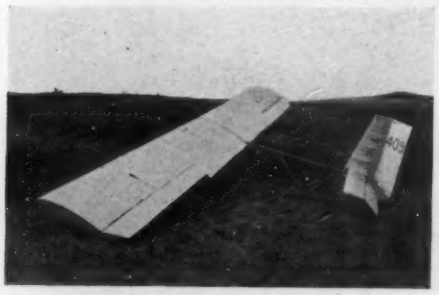
Flying the M. I. T. Glider

Designed and built by students, its test flights proved highly successful

By JAMES C. REDDIG '29
Vice-President, Aeronautical Engineering Society

TECHNOLOGY'S latest glider, whose design was described in the TECH ENGINEERING NEWS of April, 1928, has been completed and successfully flown by the Aeronautical Engineering Society. The original project was formulated in January of last year by a group of the more actively interested students, members of the Society. An original design, the work of T. E. Doherty '28, was completed in the last of February, test work on rib design was done, and construction started early in April. The usual unforeseen difficulties arose, which prevented flight tests that had been planned for the end of the school year. The summer's hot weather warped certain wooden members, and extensive changes in the internal wing structure occupied the few students on hand through the summer session. The original group of students completed the ship and made all final adjustments after school opened in the fall. On November 10, loaded on a borrowed canoe trailer, the ship was taken to the sand dunes at Wellfleet, Massachusetts, on Cape Cod, for flight testing over the Armistice Day week-end.

It was apparent that the lack of experience in handling gliders was the serious drawback of the trip. An unfortunate location was chosen for the flights, and the technique of launching a glider was wholly lacking. On the first attempt, the rubber launching rope was broken without moving the ship from where it was poised on the top of a dune; on the second, a member of the launching party fell in the path of the oncoming ship immediately as it left the ground, and the pilot skillfully brought the ship to the ground without striking the fallen man. On the third attempt, the fuselage got off the ground, but one wing tip dragged, and another minor crash resulted. The fourth attempt was successful, the ship flying about 400 feet. This flight demonstrated a lack of rudder control, for the pilot was unable to turn aside in time to avoid striking a small apple tree on landing. As these four attempts to fly the ship, and the repair work incidental to each flight, occupied the most part of three days, the ship was brought back to the Institute for changes. None of the crack-ups were at all serious, for the damage was done to the landing gear and the wooden nose which held the pilot's seat.

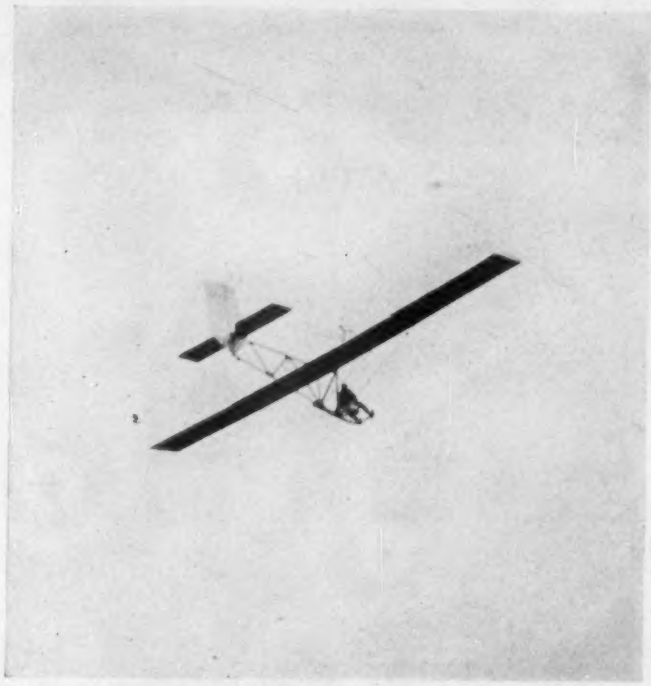


BETWEEN FLIGHTS

The open framework fuselage, wing construction, and tail group contain many unusual features of design.

The glider was overhauled during the winter, and a larger rudder was built and the fin area increased. A new control system was built and installed, the old wooden nose removed, and a new steel tube cantilever nose built onto the fuselage. The change from the wooden construction to the steel tube nose with the revised controls did not materially affect the weight of the ship. During the winter the Department of Commerce assigned the registration number 409 to the glider.

On April 18, the beginning of the spring recess, the glider was again loaded on the trailer and taken to a location selected by a committee which had visited the Cape the previous week, the new cliff being about two miles from that of the previous November tests. The ship was assembled in a little saucer in the dunes and successfully flown with no trouble whatsoever, making three hops of about 100 yards each. The next flight was started from the top of a big sand dune facing the waters of Massachusetts Bay at about 100 feet above the beach. This was the longest flight made — one minute forty-five seconds, and covering about a half mile. Mr. Kelsey, the pilot, turned south after leaving the cliff, and patrolled along and above the face of the big dune, without losing appreciably, if not actually gaining, altitude. He then executed a 180° turn, and went north along the cliff, sinking slowly until forced to turn into the wind and land on the beach. The thrilling flight fired the enthusiasm of the entire group, which had been failing as a result of a year and a half of hard work, rewarded until that time with only mediocre results. The pilot was pleased to report satisfactory control and stability and good flying characteristics.



THE GLIDER IN THE AIR

Taken on one of its twenty-two flights, this view gives an excellent idea of the position of the pilot with the ship "following along behind."

A total of twenty-two flights were made, some in the little hollow, many from the top of the big dune. At one time the launching rope broke, and the glider was released without an adequate start. The ship was turned quickly to avoid being thrown over the cliff and a cross-wind landing attempted, but the wind threw the glider over on its back. This mishap called for the only serious repair work of the trip. On the final day, with the glider still flying, each of the men remaining in the party was given the opportunity to fly it. Five flights were made by "greenhorn" pilots who had never held a control stick before in their

(*Continued on page 162*)

Editorials

BALANCING THE EDUCATION

The quantity of material that is necessary to be assimilated by the student engaged in the conventional four-year course in a modern technical or scientific school has increased to such an extent that the more general, or liberal, part of his education is sadly neglected. Indeed, it is difficult to gain all the necessary knowledge relating to his particular subject in the four years, without even considering his general education at all. Certainly the engineer or the scientist is a human being, and the means for getting the fullest enjoyment from life should be his as well as anyone's else.

There are two solutions to this undesirable situation in which he is missing something which can contribute much to his appreciation of the finer things. One is to extend the present four-year course to a period of six years. The second is to require for entrance, a two years' attendance at some college of liberal arts. The former exists in an unofficial way at present, although not very extensively, in the graduate schools. However, the second system would probably be more suited to the temperament of a technical school. There is a feeling that a technical school should deal with technical subjects alone, and this could be attained without detriment to the student if he had previous college experience in the liberal arts.

THE COVER

The Rohrbach *Romar*, an ocean-going flying boat, is the subject of the cover illustration for our Aviation issue. An all-metal ship of German design and construction, it is pictured during a test flight in the North Sea, attempting a landing in waves fifteen feet high. The artist is Prof. C. F. Taylor, of the Department of Aeronautical Engineering, who made the charcoal sketch especially for THE TECH ENGINEERING NEWS.

PLANS FOR NEW GLIDERS

The work of the M. I. T. Aeronautical Engineering Society in designing, building, and successfully flying their latest glider is an accomplishment of which it may well be proud. Since the formation of the organization, the construction of these motorless airplanes has been a major part of its work, and the gliders, which in 1922 flew in European competition, were particularly outstanding.

The latest glider was designed primarily to familiarize those interested in the work with the details of airplane, and particularly glider, construction. It was therefore made ruggedly, with a high factor of safety and great strength in the various members. That it was flown twenty-two times without the necessity of more than a few minor repairs speaks for its durability.

Although three designs are available for competition gliders with which it might be possible to attempt to capture the present endurance record of over fourteen hours, the next one will probably also be a training ship type, with a more refined design.

There has been, however, a lack of a definite program and substantial resources, without which the greatest benefit from the work cannot possibly be realized. At present, things are at a standstill. The cost of the present ship exceeded $300, most of which was contributed by those actively interested in the work. It will be necessary to finance a new glider on a far sounder basis before work can start again in earnest. The question of labor is a serious one, for many of the students who worked on the glider devoted to it far more time than they could well afford from their studies. Much of the work in the future might be done through coöperation between the Institute and the Society by regular classes of aeronautical students in those parts of their work which could be connected readily with glider construction. Here they would be gaining practical experience, and at the same time, they would have the satisfaction of knowing that their work was of value in a definite, concrete, and worthwhile undertaking.

ELECTIONS

The Managing Board of THE TECH ENGINEERING NEWS takes pleasure in announcing the following elections: E. H. Anderson '32, News Editor; R. M. Stewart '32, Assistant Circulation Manager; A. M. Maguire '32, Assistant Circulation Manager; G. D. Johnson, Jr. '32, Assistant Advertising Manager; A. B. Berghell '31, staff member.

PROFESSOR CHARLES LADD NORTON

Professor Norton has been connected with the Institute for a period of forty years. Having received his elementary training in the public schools of Springfield, Massachusetts, he entered the Institute as a member of the Class of 1893. Upon his graduation, he was appointed to the staff in Physics and given the task of setting up the Heat Measurements Laboratory, one of the earliest in which systematic instruction in heat measurements was given.

In 1900, he was appointed to the faculty. Five years later he became Associate Professor, and in 1910, Professor of Physics. In 1917, he was appointed Associate Professor of Industrial Physics, and in 1920, Professor of Industrial Physics. Upon Dr. Walker's resignation as Director of the Division of Industrial Coöperation and Research in 1920, Professor Norton was appointed to succeed him, and he has held that office ever since. In 1922, he became head of the Department of Physics upon the resignation of Professor E. B. Wilson. After the death of Dr. MacLaurin in 1921, he became one of the Faculty members to serve on the Administrative Committee which took charge of the affairs of the Institute until a new President was chosen.

Professor Norton's interests in Industrial Physics have been diversified. Following his work on the Heat Measurements Laboratory, he was associated with Dr. Francis H. Williams of the Corporation in devising ways and means of utilizing X-rays for medical diagnosis.

In 1902, he was associated as engineer with a number of others in establishing the Insurance Engineering Experiment Station. That organization assisted in the complete recognition of Portland cement concrete as a fire-resistant material, thereby making it available in a large way for construction.

During the war, he was associated in the critical study and development of numbers of new scientific devices for offense and defense. Much of this work was done in connection with the Naval Consulting Board and the Ordnance Department of the Navy. He also undertook to develop a process for the manufacture of metallic magnesium, the supply of which had been cut off from the Allies at the outbreak of the war. He succeeded in developing an electrolytic process for the preparation of magnesium, and later designed and built a plant which was able to produce the material in large quantities before the United States entered the war.

More recently he has been active in an attempt of the makers of refractories in this country to develop refractories of a superior resistance to fire and load, and to substitute new and more economical methods of manufacture. In addition to improvement in the manufacture of silica brick, he and a number of his associates have now succeeded in finding a process for utilizing the huge beds of high grade kaolin in making refractory brick.

Inasmuch as Professor Norton has been connected with so many industrial enterprises while at the same time a member of the Institute's Faculty, he has been instrumental in bringing about a closer contact and a better understanding between industrial executives and the Institute's teaching. Through his influence, better contacts have been made between the workers in theoretical physics and those interested in industrial development.

Among the professional organizations, Professor Norton is a member of the American Physical Society, the American Chemical Society, and the American Society of Mechanical Engineers. He is also a Fellow of the American Academy of Arts and Sciences.

The Engineering Field

Abstracts from the leading professional and trade journals

Blaugas, a gaseous fuel named for the German chemist, Dr. Blau, its inventor, was one of the principal advances of the Graf Zeppelin over former airships, because a greater number of heat units can be carried and an increase in cruising radius of 20 to 25 per cent becomes possible over that obtained by the hydrogen-gasoline ship.

This gas, which is a hydrocarbon gas produced from crude oil, can easily be made in the United States with combinations of existing natural gases. One of the chief difficulties in its use is that of transporting it, for the gas must be compressed into liquid form and shipped under pressure.

Structural stresses, which are considerable with heavy fuel loads, are reduced in storms or squalls, since the gaseous fuel has a density of 1.05, approximately that of air, and when stored in fabric gas cells in the ship it produces no stresses.

The main advantage, however, lies in the possibility of maintaining equilibrium between load and lift by the consumption of a fuel of the same density of air. With the use of heavier fuels, the lifting force rapidly increases as the fuel is used until a considerable proportion of the dynamic power of the ship has to be used to overcome excess buoyancy, while maintaining flight at a desired level. Valving, that is permitting some of the lifting gas to escape, reduces the buoyancy but involves loss of lifting gas, which would be an appreciable expense in the case of hydrogen, and would be costly with helium. In American helium-inflated airships, the water of combustion from the engines is condensed and collected to compensate for the expenditure of fuel.

From the standpoint of safety it is a question whether anything would be gained in the United States by the introduction of a fuel gas into helium-filled airships, for maximum safety will be obtained with helium-filled ships when heavy oil engines are used for their propulsion plants. Blaugas will probably find its greatest use at the present time with hydrogen-filled ships with their inflammable lifting gas.

Courtesy *American Gas Association Monthly*

IMMENSE GAS HOLDER

The World's Largest Gas Holder of 20,000,000 cubic feet capacity recently built in Chicago has disproved the theory that 15,000,000 cubic feet is the maximum capacity for holders, and there seems to be no apparent limit to the size of holders in the future.

Resembling an enormous close-fitting cylinder turned upside down, this gas holder weighs 5500 tons and rests on a concrete pad varying from six to eighteen inches in thickness, which in turn is carried on 480 concrete piles. Fourteen special pumps, driven by 7½ horse power motors, provide a circulation of tar to seal and lubricate the piston at the bottom. At present the holder is used with pumps giving an output of 36,000,000 cubic feet daily.

In addition to being the world's largest, this holder is also distinguished by being an official air beacon and marker, having many powerful ruby lights on its top and sides and across the top an arrow and inscription giving directions to the nearby airport.

Machine Finishing of Asphalt Pavement was successfully and economically carried out on many state highways in California during 1928 when the old concrete roads 15 feet wide were widened to twenty feet and resurfaced with asphalt.

Concrete shoulders 2½ feet wide and 4 inches thick were poured first, then a levelling course of asphaltic concrete was laid by a concrete spreader to take out the crown of the old road.

This machine incorporates a double row of rakes between two "screeds" or steel plates which extend entirely across the road and do the spreading as the whole is moved on wheels along the concrete shoulders. The rakes aid materially in producing an even surface and help prevent "shoving" in front of the roller. Then a second course is added, 2 inches in thickness, screeded and raked with a 1½-inch crown in 20 feet, and rolled. On top of this is laid a layer of asphalt 1¼ inches deep, and 5/8 inch of crushed stone. Additional surface smoothness is obtained by the use of 5/8 by 3-inch steel strips laid temporarily as tracks along the edge of the concrete shoulders.

The actual test brought out the following advantages: possible doubling of speed of laying, with consequent decrease in overhead; less inspection necessary; a slight decrease in cost of rolling due to better preparation of surface; absence of creeping or shoving in front of roller; more regular arrangement of aggregate with consequent decrease in the tendency toward displacement under heavy loads; a resulting non-skid surface; and reduction of over 60 per cent in waviness over that of ordinary hand spread roads.

The Largest Airship Factory in the world is now under construction at the Akron, Ohio, municipal airport.

The structural frame, which is different from any other airship dock in this country, consists of a series of arched trusses giving the shell a parabolic cross section. The doors, which are of novel design, are in the form of segments of a sphere supported at the top by a large pin and at the bottom by trucks running on a circular track. This shape eliminates some of the wind currents which often interfere seriously with docking and landing operations.

The structure, when finished, will be 1,175 feet long, 325 feet wide, and about 200 feet high.

An Electro-Steam Motor Coach has recently been developed and is now being tested, using a patented steaming system generating about 150 h. p.

The steam generators are of a constant generating type, using oil for fuel, are non-explosive, and are located at the rear of the vehicle. The main driving engine, an eight-cylinder, poppet valve semi-uniflow type, is located amidships under the floorboards with direct drive to twin worm gear, rear axles. A small auxiliary steam engine, operating as a central station, drives the electric generator,

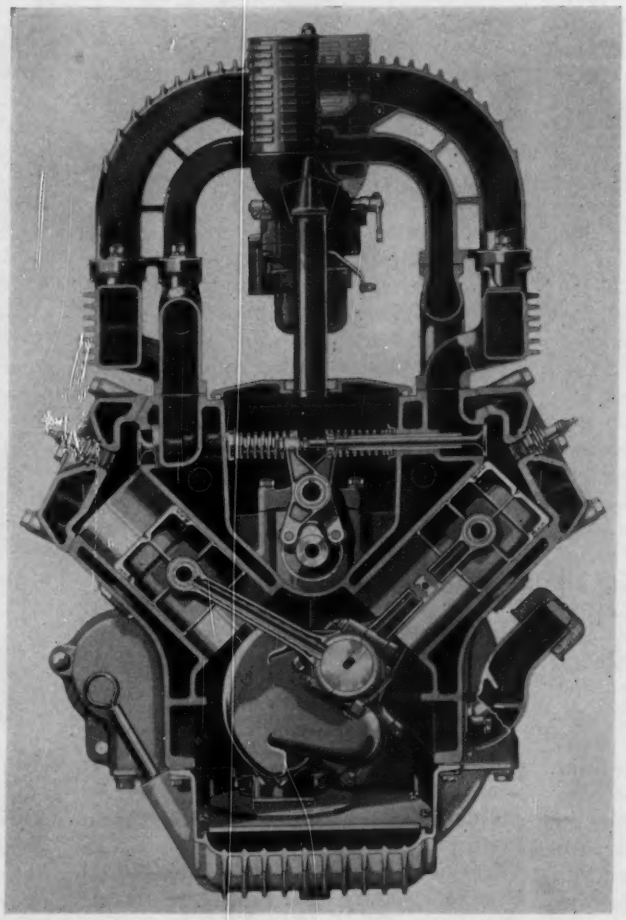
condenser fans and air compressor. Condensers are located at the front of the bus and on the roof, and all operative units are located below the floor level and designed for quick replacement.

With a Westinghouse air-braking system, capacity for forty seated passengers and a large number of standees and a sturdy design of construction, this coach, it is claimed, will lower the passenger-mile cost of operation, will lower fuel consumption, will offer less mechanical maintenance, and will increase flexibility.

The Viking, a new V-eight automobile, is now being made by Oldsmobile. This new car, mounted on a 125-inch wheelbase chassis, presents a well-balanced exterior having unbroken hood, radiator and body lines, a low set body, and well-rounded curves.

The engine is a 90 degree V-eight type, developing 81 h. p. at 3,000 r.p.m. The singular valve mechanism, which is placed horizontally in the vee of the engine, is very readily accessible and is operated by rocker arms on a shaft immediately above the chain-drive camshaft. In the crankcase the removable pan, which slopes to the rear, has transverse ribs which cool the oil and filter out solid particles from it. With the cylinder walls and the valves forming an isosceles triangle, a compression ratio of 5.2 to 1 is used without detonation. But the outstanding feature of the engine is the single casting of both banks of cylinders and the large upper part of the crankcase, which insures rigidity.

In addition to this remarkable single casting, the rear axles are three-quarters floating and have a final drive reduction ratio of 4.4 to 1, and the frame construction is heavy with side rails 6¼ by 3 inches and five channel-type cross members. Final analysis describes the car as very rigid in construction, with easily accessible valve mechanism and low, smooth body lines.



Courtesy *Automotive Industries*

CROSS-SECTION OF THE VIKING ENGINE

English Artificial Cotton, the fibre of a common weed from British Guiana which can be grown only from roots, is in no way allied to milkweed, ramie, or similar plants. It has more luster than cotton, but not so much as kapok. Its structure is similar to flax. The length of the staple varies from 1¼ inches to 1½ inches, while its average thickness is about 13.5 microns.

The artificial cotton is nearly three times stronger than Sakellarides. Taking the average tensile strength of cotton at 100 per cent, the strength of the artificial cotton varies from 160 per cent to 187 per cent. The fibre mixes perfectly with cotton, silk, rayon, and wool and presents no difficulty whatsoever with regard to dyeing and spinning.

The first commercial crop, now under cultivation in England, is estimated to amount to 40,000,000 pounds by July next, and this is covered many times over by demands from the cotton industry. In order to supply the English demand, further large tracts are being placed under cultivation at home, in Egypt, Portugal, and other countries.

Waxed Airplanes have been tested to show that the smooth surface of wax increases speed and beauty and decreases drag, corrosion, and rate of formation of ice.

The most important feature of waxed surfaces is the decrease of drag caused by skin friction. With the application of two coats of wax on a lacquered surface a decrease of 2.381 pounds per 1,000 square feet of surface area results at the speed of 60 m.p.h., and at 100 m.p.h. it is believed a great decrease will be found. The protective coating of wax also prevents destructive action of sunlight, oxygen of the air, and rain, and in addition prevents adherence of dirt, which in itself more than offsets the weight of the wax — about 1¼ pounds per 1,000 square feet of surface. Since water has no attraction for wax, the present menace of ice formation ought to be greatly reduced. Any one of these advantages should appeal to all airplane manufacturers and owners.

Electrodeposition of Rubber has been found possible by the suspension of negatively charged particles of rubber in an electric field, which causes them to travel to the anode and form into any shape or thickness. The anode used is zinc in order to remove the oxygen. The latex in which the rubber particles are suspended may be the latex from the tree or an artificial latex made by masticating reclaimed rubber with glue and water. Thus any desired rubber compound can be made and old rubber can be used freely.

This new and important process makes possible the use of a continuous wet-mix process to produce tires and other rubber products, instead of the mixing and grinding of materials in an intermittent process with consequent power requirements and loss of time.

Ethylene Glycol, a common base for many anti-freeze solutions, is to be used to replace water in cooling aircraft engines, according to Army air engineers. This clear, colorless and odorless fluid is one of the simplest of the polyhydric alcohols, and a quantity only about one-fourth that of water is needed for the same cooling effect, which results in a saving of some 84 pounds in weight. Its constituents may be obtained on the market at reasonable prices. It promises to be an important step in the development of water-cooled power plants.

An Airport Beacon has recently been erected, the beams of which are said to penetrate fog. It provides a fan of light which, when rotated, reaches a pilot at any angle at which he may approach the landing field. One-half of this fan of light is white, the other half is red, and the rotation produces alternate red and white flashes which enable the aviator to distinguish the airport from brightly lighted parks, railroad yards and streets.

Departmental Notes

DEPARTMENT OF CHEMISTRY

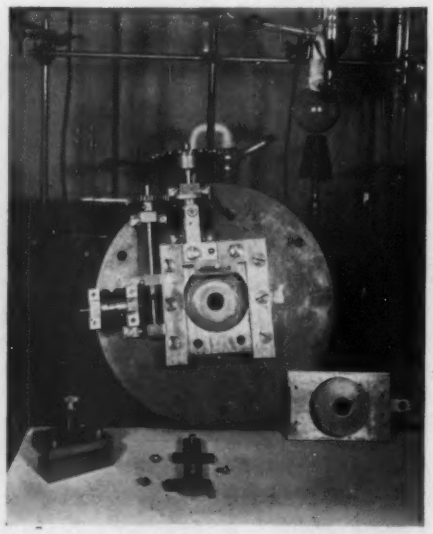
If an interested observer visited the Research Laboratory of Physical Chemistry, now just beginning its second quarter of a century of life, he would find an array of extremely ingenious apparatus for making a variety of accurate measurements of importance to the development of chemistry. In one room, he would find elaborate means for making a very exact comparison of the platinum thermometer scale with gas thermometers. Here, also, he would see an imposing collection of several examples of each of the three types of platinum thermometers, all of which have been beautifully constructed in the laboratory. Incidentally, the platinum resistance thermometer is now the universal secondary standard for temperature measurement. In another room, he would see apparatus for studying equilibria involving gases, particularly the means for measuring the heat of adsorption of hydrogen on palladium. In yet another room, he would discover apparatus for measuring the properties of strong electrolytes by determining the freezing points of their solutions with an accuracy of two or three hundred thousandths of a degree.

The work on the properties of steam at high temperature and pressure has been progressing for several years. Recently this work has had a most gratifying success. The ultimate aim was to furnish greatly extended steam tables. In order to facilitate matters, the whole problem was divided into three parts. The Bureau of Standards has been measuring heats of evaporation, at Harvard University the Joule-Thomson effect has been studied, while at Technology attention has been centered on the pressure-volume-temperature relations. Only a few weeks ago, it was shown that the three different groups of studies had all given data which led to the same conclusions as to the properties of steam at high temperatures and pressures.

One of the most interestingly constructed devices is designed to study the activity of single molecules or atoms of a gas. This apparatus has been named a Molecular Ray Calorimeter. At ordinary pressures, the diminutive gas particles are in continual motion in all directions, constantly colliding with each other and beating an inaudible tattoo against the walls of their confining vessels. By means of suitable diaphragms and very high vacua, an exceedingly fine beam of atoms can be directed against a target especially prepared to detect and measure some particular effect. Thus the heterogeneous motion is replaced by one which is uni-directional. No longer are there any collisions between the gas particles — only their continuous spatter against the target remains. This may be much like a stream of bullets from a machine gun, or if it could be heard, might be reminiscent of a long, unbroken roll of drums. Studies with this apparatus offer a direct means for obtaining much more exact knowledge of heats of chemical reactions, of heat capacities, of heats of fusion, and of the speed of chemical reactions.

There are a number of other problems engaging the workers in the Physical Chemistry Laboratory. These include studies on the properties of the rare gases, *e.g.*, argon; reactions in liquid ammonia; oxidation-reduction potentials of complex acids and other complex ion formations; measurement of dielectric constants under pressure, which, it is hoped, will give greater insight into the molecular states of gases and liquids; and the determination of the freezing-points of certain very pure organic compounds, which may be used as temperature standards. This latter work is more or less in conjunction with the Reichsanstalt and the physical laboratory of the University of Leiden.

The laboratory is equipped, further, for optical studies. A large room has been fitted with a quartz spectrograph (Hilger E-1). In this room, researches are in progress on the ultra-violet absorption of gases and chemical reactivity as related to atomic structure.



THE MOLECULAR RAY CALORIMETER

An apparatus for the study of the activity of gas atoms and molecules.

Although the physical chemists are pressed for room, the Research Laboratory of Organic Chemistry is somewhat more congested. On this account it presents a very different picture. Here the observer would see an almost bewilderingly compact collection of apparatus — fractionating columns, high vacuum pumps, shaking machines, balances, thermostats, ultraviolet lamps, ozonizers, equipment for measuring such optical properties as refractive indices, apparatus for semi-micro combustions, devices for catalytic reduction, and so on. Not a square inch is left unoccupied. Within the set limits of space, however, there is good equipment for advanced studies. To a considerable degree the privation occasioned by the lack of space is offset by an *esprit de corps* among students and staff. An atmosphere of enthusiasm for the study of chemistry pervades the laboratory.

The variety of problems upon which students are engaged reflects the widely different special interests of the members of the instructing staff. One of the chief problems is a comprehensive study of the factors influencing the reactivity of groups in organic compounds. To this end, studies are under way on the lability of bonds as measured by stability towards heat, on the mechanism of esterification, on the reactivity of the hydroxyl group with special reference to cellulose, and on the lability of the carbon-chlorine bond. The work on methods for the identification of pure organic compounds, which has been continued over many years, remains one of the major interests.

Researches on the oxidation of phenols are devoted to the factors determining tautomerism and to the effect of groups on the reactivity of quinones. Studies on urea, thiourea, and guanidine and their derivatives, which are being actively pursued, already have yielded a good deal of new information on the reactions of the simpler compounds of nitrogen. Another absorbing problem concerns the preparation and examination of metal pyridine complexes, like cupric hexapyridine cyanate.

A further group of researches covers a study of the influence of structure on the chemical reactivity of the olefines, the paraffins, and the aromatic hydrocarbons, with special reference to the development of analytical methods applicable to mixtures. Besides these studies there is work in progress dealing with condensations of the benzoin type, with trivalent car-

(*Continued on page 162*)

All the world's a campus

It may appear a vast jungle of smoke-stacks and buildings, blind alleys and not very definite possibilities.

But there are those who say it is as interesting, as colorful, as alive as any college campus. And why shouldn't it be? The world, too, needs menwho are leaders of men. Men who can do new things. Men who can make new records.

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Elementary Differential Equations. By THORNTON C. FRY, PH.D. *D. Van Nostrand Co., Inc., New York City. 255+x pages. Price $2.50.*

This book, written for engineering students and prepared originally for use in the Out-of-Hours Courses in the Bell Telephone Laboratories, has an aspect differing largely from the conventional college textbook. All the matter usually contained in an elementary course in differential equations is to be found in this book, but the method and order of presentation is original and well adapted to arouse the interest of a reader who wants to know the use of differential equations rather than to learn formal manipulation. The numerous applications to definite scientific problems help to keep up interest. At the same time, the author emphasizes the importance of understanding theoretical considerations which are the basis of all the work.

As an illustration of the method of approach, we notice that the author postpones until the fourth chapter the discussion of integrating even the simplest differential equation. Before that, he has discussed the significance of a differential equation and the manner in which it arises in practice. In the former discussion, the graphical solutions of equations of the first and second order are used to visualize the meaning of a solution, and the importance of boundary conditions is emphasized. The discussion of the manner in which an equation may be derived from its primitive is dismissed as of little practical importance, but numerous applications from physics are given. These include such a variety of topics as chemical reaction, a freely hanging string, the flow of electric current, the conduction of heat, the motion of fluid, and the potential in a vacuum tube.

Again, after a chapter on methods of solution, we find applications to the flow of heat in a wire and in a sphere, trajectories, falling bodies, bending of beams and columns, vibrating string and drumhead, the minimum surface of revolution, the brachistochrone, geodesics, the problem of Dido, and finally a problem of probability arising in telephone operation.

In the discussion of linear equations, as is natural in a book prepared for use in the Bell Telephone Laboratories, there is a large use of operational processes and numerous applications are made to electrical problems.

The reviewer has only one criticism to make, which is after all more of a query. Why does the author spend so much space on the theory of envelopes, including the tac- and nodalloci, and their connection with singular solution? There seems to be no practical application in the book involving such mathematics.

FREDERICK S. WOODS.

Prometheus, U. S. A. By ERNEST GREENWOOD. *Harper & Brothers, New York City, 1929. 213 pages, illustrated. Price $2.50.*

Epimetheus, so runs the Greek legend, was given the task of providing man and all the other animals with the faculties necessary for their existence and preservation. He progressed fairly well until he came to man, where he discovered that he had been too lavish in his gifts to other animals, such as strength, swiftness, wings, and claws, that he had none left for man. Prometheus, his brother, therefore stole into heaven, lighted a torch at the chariot of the Sun, and gave man the gift of fire which has, more than any other, made him master of the world. The story of fire is the story of civilization. As fire progressed from a flickering community fire to the roaring blast furnace, so civilization progressed. The author even traces woman's position in the scheme of things to fire, for the necessity of keeping the hearth burning made woman's place definitely in the home. Today, the introduction of modern automatic heating may be the cause of the decay of our traditional home life.

Mr. Greenwood starts his subject back in the dimmest traditions of the past and brings it forward to the present. The inclusion of the old myths and legends regarding the origin and early history of fire and fuels adds greatly to a subject already interesting.

Wood, the first fuel, was the foundation upon which our early country was built; even our first locomotives were fired with it. The author takes up the problem of available and future supply. "True conservation," he says, "does not mean the withholding from present use of the Nation's natural resources." Intelligent use, not hoarding, should be the keynote of all conservation programs.

Wood was gradually replaced by coal as the major fuel, and upon coal the foundations of American industry are built. Without coal, our modern steel buildings, transportation systems, machinery, iron works, and all that depends on them would have been impossible. Yet as late as 1808 a public demonstration of coal burning was a great event and people came from far and near to see the rocks burn. Coal is now so basic, "it will be a long, long time before it is entirely replaced by oil, water power, or some synthetic fuel."

Gas is next discussed by the author, and it is greatly enlivened by interesting anecdotes concerning the public's reaction to this new fuel.

Several chapters are devoted to the story of petroleum and oil heating, and then, having concluded his discussion of fuels, the author devotes a very interesting chapter to the present and future importance of coal, oil and gas. Coal, as a direct source of heating and power, will be definitely out of the running. Burning of raw coal is wasteful, not automatic, dirty, and harmful to health. This does not mean the passing of the coal industry, by any means, but merely its reorganization on a different plan. The relative advantages of oil and gas are discussed but no definite conclusions are drawn. The author points out the often overlooked fact of distribution. Gas is not in a position to supply the country without an extensive enlarging of mains. This huge capital expenditure would greatly increase the price. Oil, on the other hand, is distributed in tank wagons which could be gradually increased with the demand. The question of seasonal loads also reacts against the gas company.

Mr. Greenwood rounds off his book with chapters devoted to the political side of the question, recommended legislation, national defense and oil, and research. The legislation proposed by the Committee of Nine appointed by the Federal Oil Conservation Board to allow combinations and agreements among oil producers would be, in the author's opinion, a great step forward in conservation and prevention of overproduction.

"Prometheus" is very easy to read. The author's style and treatment have combined to make a book of value to the technician who seeks a broad viewpoint, and of interest to the layman who, after all, will finally decide the outcome of the battle of the fuels.

C. F. E.

Blasting Circuits

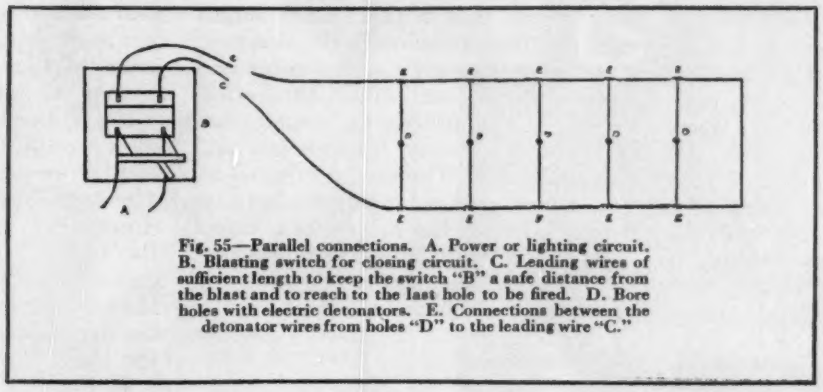

Fig. 55—Parallel connections. A. Power or lighting circuit. B. Blasting switch for closing circuit. C. Leading wires of sufficient length to keep the switch "B" a safe distance from the blast and to reach to the last hole to be fired. D. Bore holes with electric detonators. E. Connections between the detonator wires from holes "D" to the leading wire "C."

Lesson No. 3 of

BLASTERS' HANDBOOK

EVEN the way that wires are twisted together in making connections has an important bearing on proper use of explosives. Electric blasting is hedged around with most elaborate rules and precautions. There are series and parallel connections, parallel series and series parallel circuits. Blasting machines or power circuits for electric blasting are surrounded with great mystery.

In Chapter Three of the *Blasters' Handbook* this matter of blasting circuits is illustrated and comprehensively described. The selection and use of galvanometers, rheostats and blasting machines are explained. Tells how to prevent misfires, how to test a circuit, how to locate a break, how to use a resistance table and many other practical phases of blasting circuits.

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TE-5

Beams in Bending

(*Continued from page 139*)

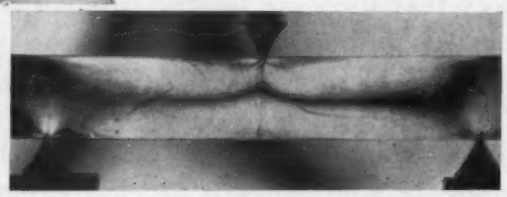
longitudinal extension, rather than more loosely as a line of no stress.

Fig. 3 may be considered as a map of the stress directions in the 10-inch cantilever beam with 5-pound concentrated load. As will be seen later, it corresponds very well with the theory, except near the point of support. Superposed on the figure is a diagram of stress, calculated and observed, in the most strained fiber on the tension side. It may be seen that the agreement is quite good except near the root, where the observed stress rises to a high value. Such variance may be expected in any case where local stresses may arise; in particular the presence of a sharp reëntrant corner in any structure almost invariably results in a sharp rise in the stress curve, which increase may be eliminated or reduced by the use of a fillet with smooth, easy curvature.

The same particulars for the 5-inch beam with 10-pound load are given in Fig. 4. We note again the high stress at the sharp corner, and also the observed stress, which is now greater than the computed values at all points. We may expect that if the loaded length were still further reduced, the observed stresses would come to differ more and more widely from their theoretical values, as the underlying assumptions of the beam theory became less and less applicable. The case portrayed by Fig. 4 is of particular interest here, as it may be made the subject of a direct comparison with the succeeding figure.

In Fig. 5, the theoretical distribution of the isoclinic lines and lines of principal stress are shown for a cantilever beam 5 inches long with a concentrated load at the end. The method by which these lines were determined can be found in Vol. II of Fuller and Johnston's Applied Mechanics. It can be seen that the results shown in this drawing do not vary greatly from those experimentally determined except that the case here considered portrays an ideal condition, difficult if not impossible to arrive at in practice. The 45 degree isoclinic line passing through the center of the beam has already been confirmed by the actual photographs in Fig. 2.

(*Left*) The ten-inch beam of Fig. 6.



(*Right*) The five-inch beam. Theory requires these loci to coincide with the central line, B. Actually, they diverge at the loads.

FIG. 7. BEAMS IN PLANE POLARIZED LIGHT

A simply supported beam may be thought of as two cantilevers placed root to root, the only differences being small variations in the manner of applying the loads. Fig. 6 shows under circularly polarized light a 10-inch and a 5-inch beam 1x1¼-inch section simply supported at the ends and loaded by concentrated weights in the centers. We note again only a faint line of pure shear in the longer beam and none at all in the shorter one. The dark lines near the central loads are not the shadows caused by pure shear, but are the areas of high color intensity in the regions of high local stresses.

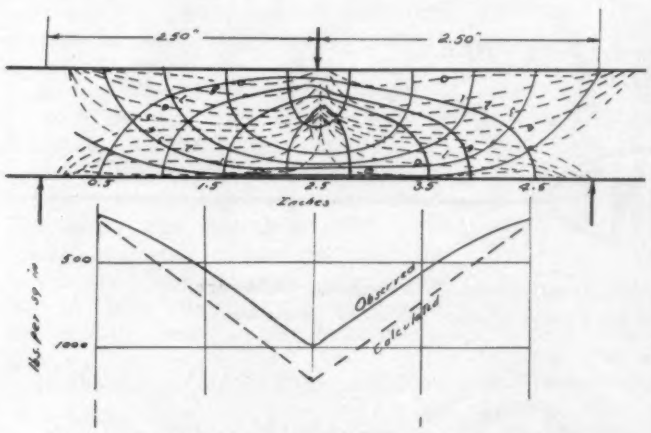


FIG. 8. EXPERIMENTAL STRESS DISTRIBUTION IN A SIMPLE BEAM

Although knife edges are employed for the load and supports, exact symmetry is not obtained.

Fig. 7, taken in plane polarized light, shows in the 10 and 5-inch beams, (*A*) and (*B*) respectively, the loci of points where the principal stresses are inclined at 45 degrees to the lengths of the beams. The common theory requires these loci to be coincident with the central lines throughout, actually the divergence is appreciable only near the loads.

In Fig. 8 is shown the experimentally determined stress distribution for a short beam supported at the ends having a concentrated load at the center. It is interesting to note that, while knife edges were employed for the load as well as the supports, the stress distribution is not exactly symmetrical about an axis passing through the load. This can be seen by examining the isoclinic lines and lines of principal stress. The two families of interlacing loops showing the directions of the principal stresses, while differing from the beginner's idea of what this pattern should be, are strictly true, and not due to the fact that the beam is very short as compared to its depth. A 10-inch beam supported and loaded in the same fashion gives a pattern essentially similar to that of the short beam, the isoclinic lines, however, grouping closer and closer to the center of the beam as the length/depth ratio is increased.

The outside fiber stress on the tension side of the beam is shown plotted at the bottom of the figure and the disparity between the observed and calculated values becomes very noticeable as the beam is shortened. The difference in the shapes of the observed and calculated curves can be explained by the fact that, even in actual experimental work, it is not possible to arrive at the ideal boundary conditions necessarily assumed for the calculations.

Industrial Physics

(*Continued from page 135*)

istrative responsibility. To the latter class of men there naturally come greater opportunities and greater remuneration, and the administrative head of a large research laboratory of course commands a materially larger salary than the individual workers of the staff, and often rates with those of the principal executives of the company.

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Airplane Engineering

(*Continued from page 137*)

thorough knowledge of fundamentals, and a great amount of experience.

The amount of work necessary for the laying out of the most important aerodynamical parts of a new ship, is by far, lessthan most students of aviation suppose. As we cannot, and do not build radically new and different ships but develop one type from the other by increasing or decreasing dimensions, pay load, horse power, etc., ships built by the same firm or designed by the same engineer have, to a certain degree, of course, the same characteristics. That is in regards to aspect ratio, wing section and plan shape, ratios of tail length and tail surfaces, etc. The number and type of engines to be used in the new design is almost always decided upon previous to the first layout sketch. The multi-engined ship seems to come more and more into general use. The question whether two or three or more engines are to be used is still very widely discussed. The safety is higher for the three-engined class, as most three-engined ships, now in use the world over, are capable of flying on two engines only with normal useful load; whereas only a few twin-engined ships can fly on one engine with full useful load.

The first trouble comes from the analysis of the detail weights of the empty ship. Up to now there is not available in any books or magazines, figures on weights per square foot of different wing constructions, fuselage, landing gear and tail surface weights, etc. If the designer has not kept for his own use, *i.e.*, of course, for his company, a complete detailed record of such weights from previous ships, he is absolutely in the dark. He can expect a great surprise when he first scales his finished ship, as it has been often said before, an airplane can be classified a success or a failure the moment it has been put on the scales, and a check made of its actual weight.

We repeat, designing is an art; not only in the realistic sense in being able to find the way out of a thick forest of regulations, specifications, demands of the operators, sales department, and also treasurer of the manufacturing concern; but the finished ship must have an artistically pleasing effect, not only because of the psychological reaction of the purchaser and the public, but also because it is generally true that a ship which looks good also is good. A good-looking airplane must have a certain balance of lines and curves, of areas of tail surfaces, a certain cleanliness all around, and a simplicity which will give the appearance that everything on the ship has been designed as one harmonious cast.

Odd shapes for the sake of being odd only to be different from other ships have often proved to be detrimental to good performance. Proper outside paint colors and matching have, of course, great influence on the appearance of the ship, as well as to its size in bringing out characteristics in areas and lines.

When the general lines and detail weights of the ship have been determined, the work has only begun. The next step is the preliminary stress analysis of wings, fuselage, landing gear, tail surfaces, control system, etc. The fuselage may be designed correctly to stress analysis, all requirements of landing and flying loads may have been considered, but still there are other requirements which must be remembered: For instance, the vibration coming from engine and air forces and what may be termed the "grip factor." Only experience can tell how certain members have to be proportioned or braced in a different way to avoid

(*Continued on page 156*)

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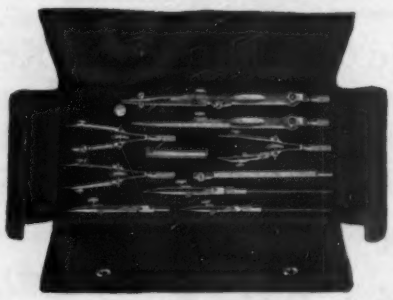

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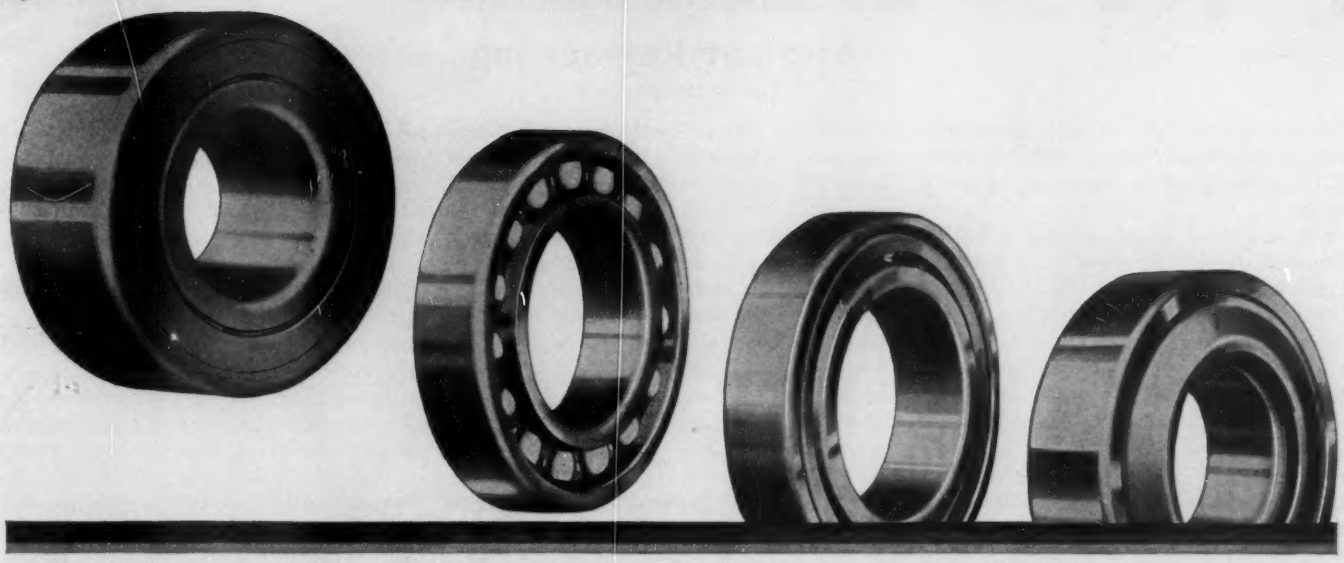

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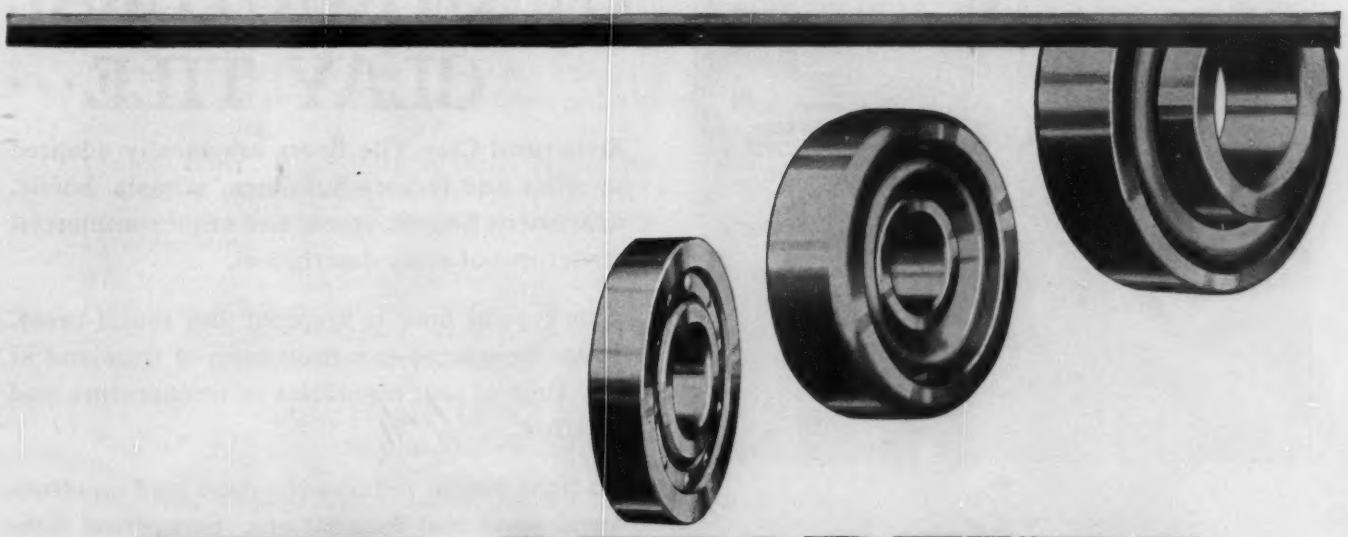

NEW DEPARTURE

BALL BEARINGS

1276

Airplane Engineering

(*Continued from page 154*)

vibrations and also which members have to stand the "grip" of mechanics, pilots, passengers or baggage, in daily service.

We know of cases where so-called all-metal ships, *i.e.*, ships built entirely of aluminum alloy, have developed vibrations which became dangerous. Different members and plates vibrated at different pitch and speed and for a certain length of time these different vibrations could not be felt because they equalled each other in opposite direction; but then came periods at even intervals when the vibrations added up a sort of shiver through the whole ship. Vibrations of such kind tend to loosen all riveted or bolted connections and bring a fatigue in the material which may cause serious trouble. In this case the ship was perfect from the stress analysis viewpoint, and still it could not be termed a perfect ship.

Fuselage bottom longerons near the tail of the ship have to be made stronger than the stress analysis demands. One reason for this is that the mechanics or field help have the habit of lifting the tail not at structure points but on the longeron between the verticals of the truss, thus bringing a bending load in the structure which had not been taken into account in the analysis. Another reason is the existence of wheel brakes. With the introduction of brakes on landing gear wheels new loads were added to those already carried in the bottom truss of the fuselage. Pilots saw that they could swing a ship around in very small space by blocking the inner wheel and opening the engine throttle, or the throttle of the outer engine on trimotor ships. They did not see their tail skid skimming over the ground! This swinging of the ship around the inner wheel on a turn creates a considerable side load at the tail end of the fuselage and has to be compensated by increasing the sizes of the fuselage members if permanent setting and fatigue is to be avoided.

Brace struts for wings or tail surfaces are other items for which stress analyzing alone is not sufficient. Again vibrations created by engine or airforces are to be considered. Where lift struts are subjected to interchanging compression and tension the closest ream fit at attachment points is necessary to avoid premature wearing out of bearing parts. Sometimes it has been proven to be advisable to use tension cables to create compression in the streamline tube strut, to avoid vibration.

Many different types of fuel and oil tank construction are used, terne plate, brass, aluminum alloy riveted, aluminum welded, each designer having a certain preference for one type or the other. Lately it seems that two types are becoming more and more generally used, the aluminum welded, and the aluminum alloy riveted tank. Both types have their design characteristics which cannot be learned from books. The aluminum welded tank must be designed so that expansion of the material during the welding process does not bring permanent stresses in the tank shell or end plates, because then the tank would soon start to leak in service, and the riveted tank has to be designed and manufactured so that the rivet seam is gas tight and that vibrations do not strain the connections.

The commercial airplane is a transportation vehicle and has as such to serve the public in the same way as a common carrier. This means instal-

(*Continued on page 158*)

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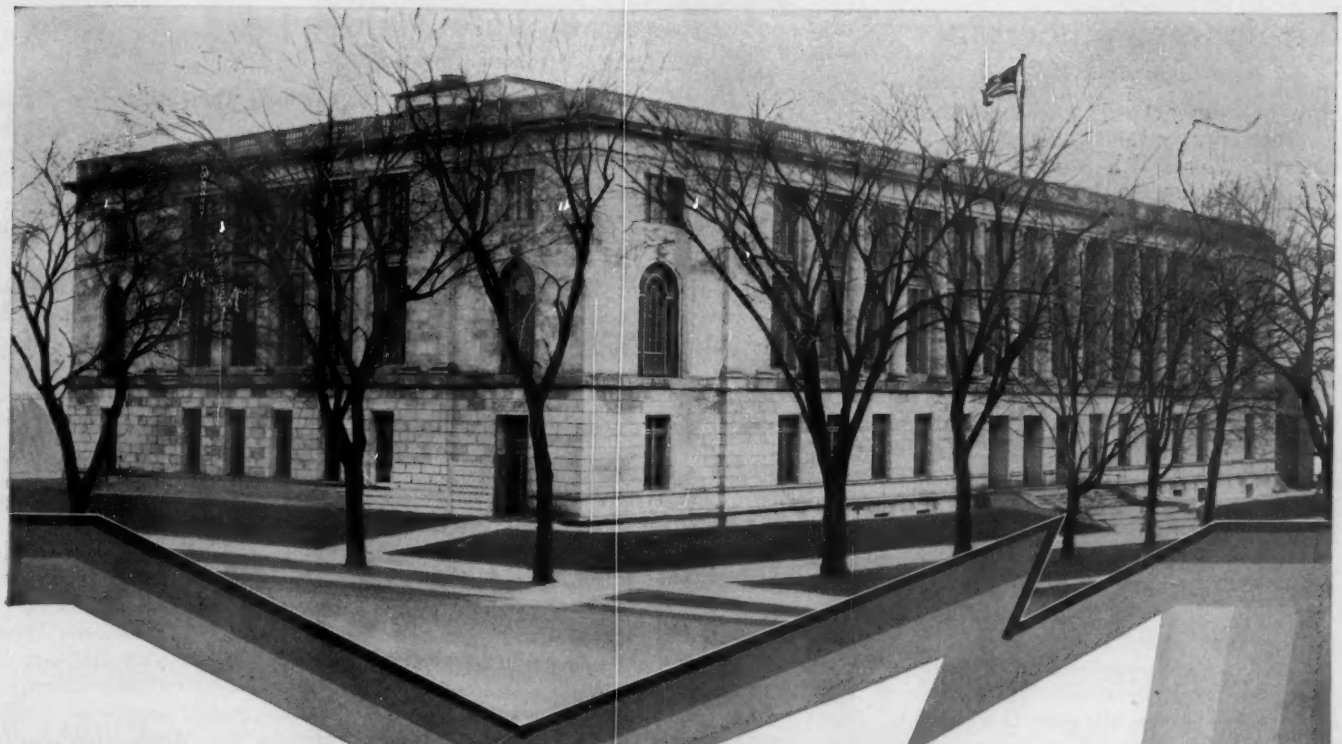

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for Federal Building

Probably one of the most interesting and attractive of the federal buildings erected during the last year is the United States Post Office and Court House at Madison, Wisconsin. In addition it is one of the first in the building program resumed since the World War.

Situated in the shadow of the state capitol and only a few hundred feet from Lake Monona, one of the four lakes which surround Madison, the three-story building of Bedford stone has an ideal setting.

Employing the latest methods in the interior transfer of mails the Post Office department arranged the rooms, conveying machinery and platforms to bring about greater ease and speed in the handling of all classes of mail.

In the main lobby, marble slabs cover the walls from the floor to a height of eight feet. Quarter-sawed oak is the interior finish throughout the building.

Despite other unique features found in the Madison Post Office, its foundation of dominant strength concrete is similar to that of other well-known building projects throughout the world — concrete mixed by a Koehring.

The ingredients of concrete are the same in all cases but the Koehring re-mixing action — a fundamental principle of Koehring concrete mixers and pavers — coats every particle of sand and gravel with cement to produce dominant strength concrete.

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"Concrete—Its Manufacture and Use," a complete treatise and handbook on present methods of preparing and handling portland cement concrete, will be gladly sent on request to engineering students, faculty members and others interested.

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KOEHRING

Airplane Engineering

(*Continued from page 156*)

lation of comfortably upholstered chairs, heating systems, electric light, toilet equipment with running water, good ventilation system, windows, floor matting, pleasing ceiling and wall decoration, etc., depending upon the quality of the service to be rendered. Practically every item must be newly developed because of the weight and space question, and cannot be taken from present bus or railroad experience.

Two or three years ago airline operators were satisfied when they could offer their customers a plain and simple cabin with a few wicker chairs; a cabin which kept the passengers protected from the hundred-mile gale blowing outside was considered sufficient.

Improvement during the last year did not stop, however, with beautifying the passenger cabin only; the pilot's cockpit has also been freed of all control cables, levers here and there, pipelines, electric wires all over the place and the disposition of all necessary instruments now appears well thought out.

With increase in quantity of production, the designer must investigate replacement of complicated welded-up fittings by steel castings or forgings. As it is, of course, impossible to duplicate the exact design of the old type welded fitting in a new forging, this particular part and probably other adjacent items have to be entirely redesigned. At the present time heat-treated aluminum alloy castings are also used to great extent and give very satisfactory results. Die castings and stampings are only a question of production economy.

In conclusion, I want to bring home the thought that while airplane engineering may include design, manufacture, test and operation, it is essentially a branch of transportation engineering. The degree of success that the airplane will meet in our transportation system will depend a great deal upon the ability of the engineer to understand this problem and realize the best solution. Let us not forget that the greatest asset of the airplane is its speed.

The Senior's First Job

(*Continued from page 133*)

For the past two years President Stratton has sent to members of the graduating classes an inquiry regarding positions offered them and their reasons for choices made. Reasons for choice included the following, listed in the order of the number reported as the controlling factor in the decision:

Chance for experience.
Favorable impression of employer or representative.
Opportunity for promotion.
In line with M. I. T. training.
Location near home.
Location personally agreeable.
Large organization.
Concern highly recommended.
Location afforded opportunity to look for other openings.
Concern offered best training course.
Position offered opportunity for travel.
Position offered opportunity to continue studies.
Small organization.
Position offered highest salary.
Location offered opportunity for home life.

It is interesting to note that opportunity to gain experience is a dominating factor in the selection of a first position and that the initial salary seems to be distinctly a lesser consideration. Careful attention to opportunity for further study, to the type of concern and its organization, its program for training new employees and intelligent supervision of their work, and opportunity for promotion, indicate that in the main our seniors have a wise thought for the future as well as for the immediate prospect.

Happily more and more of our graduates realize that, for the professional man particularly, study does not end with the college course or even with the industrial training course, corresponding, as in a sense it may, to the experience of the medical interne, but that for leadership in science and engineering constant contact with leaders in one's profession, wide reading, and study are essential.

The greater opportunities in this direction afforded by the larger concerns, through their research departments and relatively larger numbers of trained executives and specialists, present attractions over the smaller companies. On the other hand, the opportunity for more intimate association with the major executives, and possible earlier opportunity for partnership and active interest in the business, makes the smaller concern more attractive to a considerable number.

"Is the better opportunity for me with a large or a small concern," and "what salary should I expect to receive," are perhaps the two outstanding questions propounded by the senior to Heads of Departments and to the Personnel Office. Both questions depend much, in the last analysis, on the individual, on his own fitness, on his personality, and his requirements for comfort and happiness. To one, this may mean agreeable occupation, joy in his work; to another, success may be more definitely represented in dollars and what they can procure.

Self-analysis is of greatest importance in determining the choice of a career. Careful study of oneself, of one's strong and weak points, as related to the requirements of different fields and occupations, is most important. Consideration of one's fitness and of the requirements and opportunities in six broad occupational fields of General Administration and Management, Production, Engineering and Design, Merchandising and Sales, Research, and Teaching, should be helpful.

And what are the requirements of the employer in considering the senior for possible association in his business? Of course he expects scholarship and generally the Technology degree is sufficient guarantee in this connection, though in some instances the call is for men only in the upper half or upper third of the class. For highly technical and research work, often only men of outstanding scholarship will be considered. Almost uniformly,

(*Continued on page 160*)

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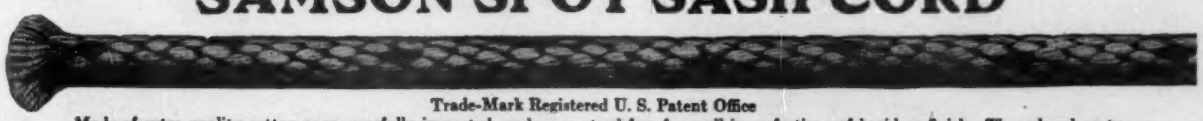

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Improper handling and use include a greater number of unsafe or inefficient methods than can be enumerated in one advertisement. However the principal ones will be discussed in detail in a series of advertisements of which this is the first. We are publishing this series in the hope that it may help to improve methods of using explosives. We invite correspondence from those who wish further information on the subjects treated. Please address Hercules Powder Company, (Incorporated) Wilmington, Delaware.

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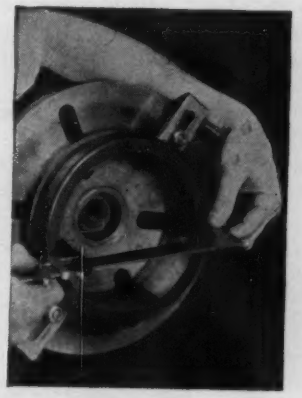

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The Senior's First Job

(*Continued from page 158*)

the first and stressed inquiry is for high character and integrity. Loyalty and industry are stressed. Good appearance and pleasing manner are carefully considered. Mental alertness, keenness of perception, the ability to think a problem through from beginning to end, logically, clearly and concisely, are important. Perseverance, regardless of obstacles, cheerfulness and good temper, are subjects of active inquiry. Coöperativeness, ability to work for and with others, leadership, ability to happily and successfully direct the work of subordinates, are likewise given careful attention. Keenness of observation, power of expression, both oral and written, are qualities keenly sought and highly rated. As bearing particularly on coöperativeness and leadership, employers are interested to know of a candidate's participation in extra-curricular activities. Undergraduate employment and the extent to which a student has paid his own way through college are items of interest when employers look for men.

Typical of the attitude of the employer is the following statement of a high business executive:

"I suppose the thing that carries most weight in my case is the general impression the man himself makes, which, in a general way, depends on personality in its broadest sense. Probably the thing of first importance is whether or not I like the man. Second, what degree of enthusiasm his system contains, and third, what his record has been. If he did not pass on either of the first two points, one hundred per cent in the third qualification would not qualify him. On the other hand, if his record was poor, a superlative degree of qualification in the other two would not be sufficient.

"As to record, I suppose the most impressive thing to me is whether or not he is a man who accomplishes things. The man who impresses me most on this line is the man who has partially or wholly worked his way through college and in addition has done well in his studies. If besides this he has participated successfully in extra-curriculum work, that is still more impressing. In other words, that gives a picture of a man who really knows how to handle himself and his time.

"If a man has but partially worked his way through college, he is apt to knows omething about the seamy side of business. He is more apt to realize, at the time some other company tries to inveigle him away, that there are probably 'thorns on the other rose bush.' He is more apt to be patient in his hurry to get along and therefore will probably stick it out."

Perhaps quite as important and pertinent as consideration of the valuable details already enumerated, is a suggestion by a former president of the Institute, Gen. Francis A. Walker. The writer had sought the president's advice regarding acceptance of a certain position. General Walker declined to comment on the particular position and the desirability of its acceptance, stressing the importance of the assumption of that responsibility by the individual himself. But, said he, "I'll tell you something that will be of greater value to you than any advice I can give regarding this particular opportunity. Wherever you are, whatever you are doing, or whatever your position, remember to do the job a little better than the boss expects you to; there's always somebody looking for that kind of a man."

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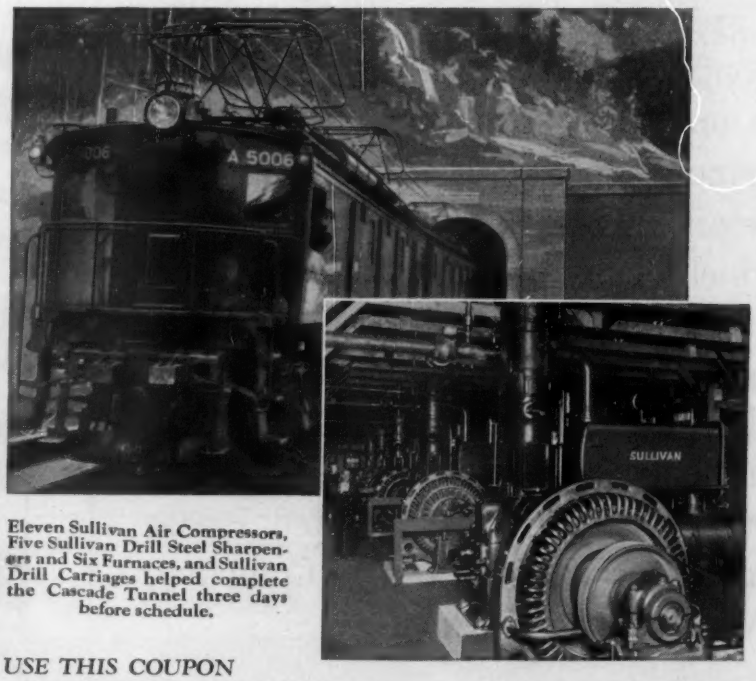

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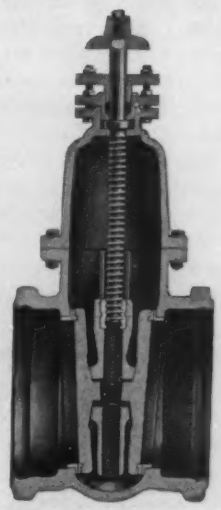

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Flying the M.I.T. Glider

(*Continued from page 144*)

lives. Some were ludicrous to watch, some really good for beginners. All of them were short flights ending in reasonable landings, with no more serious mishaps than a few damaged aileron ribs. On the last flight, however, the glider was again turned on its back and somewhat broken up, in spite of the fact that the pilot on this trip had had long experience with ordinary airplanes. Due to cold and rain, no attempt to repair the ship was made, but it was brought back to the Institute where it now awaits repairs. A number of these were flown in competition in glider meets both here and abroad, others were purely experimental or training ships.

The Aeronautical Engineering Society has a record of nine gliders, either the property of the Society or of its members individually, since its founding in 1909 as the Aero Club of M. I. T.

Plans will be available during the coming year for one or more new gliders of improved design, based on the experience gained with the present ship. Undergraduates who have been intimately connected with this plane will be back next fall to continue the work. New men, returning from summers spent in the aircraft industry, will be available, trained and fitted, to construct the new ships. Wings and tail group are now on hand for a new biplane type glider, but much work will have to be done before this can be completed. The present glider has cost $300 for materials alone, $200 of which has come from the pockets of those men connected with the work, and the remaining $100 from contributions from various sources about the Institute. These sources of revenue are substantially closed if the whole cost of a new glider is to be considered. If adequate financial arrangements can be made, the work which has been so well started can then be continued and the invaluable training thus afforded the students remain available.

Departmental Notes

(*Continued from page 148*)

bon; with induced oxidations; with the chemistry of the phenanthridone series; with diphenic acid; with the colors of mono-salts and di-salts of holoquinonic compounds; and with rates of reaction.

About a year ago the Research Laboratory of Inorganic Chemistry was organized as a separate division of the department of chemistry. Last autumn this laboratory was formally named the Henry Paul Talbot Laboratory, in recognition of Professor Talbot's long and distinguished association with the department of Chemistry at the Massachusetts Institute of Technology. Considerable equipment has been installed in three rooms and during the present school year researches have been started on several problems. A group of studies has been instituted to further our knowledge of reactions in non-aqueous solutions as in liquid ammonia and liquid sulphur dioxide. A beginning has been made on the investigation of the very interesting effect which a glow-discharge may have on chemical reactions. Other studies have to do with the chemistry of silicon and beryllium, a search for oxides of bromine, and the preparation of the inorganic salts of dichloracetic acid.

In the conference room adjoining the Henry Paul Talbot Laboratory there is an excellent portrait of Professor Talbot. A number of volumes from his library form a nucleus for a special collection of books.

In connection with the work in all three of the research laboratories there are weekly research conferences where problems of research are rather thoroughly discussed. Each week there are Journal Meetings where recently published papers are reviewed. Both staff members and students take part in these discussions. From such meetings there grows a broadening interest in chemistry.

One of the problems before the entire staff is that of scrutinizing the teaching of chemistry in the undergraduate years. A committee has been at work for some months for the purpose of correlating the many courses offered and reducing their number in the interest of more effective teaching and greater stimulus to the development of the student.

The department has resources with which pictures may be purchased from time to time, thus to present, in a definite way, the romantic history which chemistry has enjoyed. Along the corridors of the first and second floors of Building Four hang photographic reproductions of many of the great workers in all fields of chemistry. Their presence is like a cloud of witnesses bearing tribute to the exacting devotion which the science of chemistry demands of her followers.

AVERY A. ASHDOWN.

South America

(*Continued from page 136*)

amount of work in hand, the requirements of business are usually more stable, involving more continuity of progress than usually falls to the lot of the engineering technician.

In presenting these facts, it has been the desire of the writer not to discourage the young engineer with a taste for experimenting, but rather to lay before him a few general facts to guide him in his study of the question. In any case, the interested person should make it a point to get in touch with the head offices of some of the large corporations in this country which are operating in Latin America, and talk with their personnel and other officials connected with foreign work. Their intimate first-hand knowledge of conditions cannot but be of assistance to him in planning his own future.

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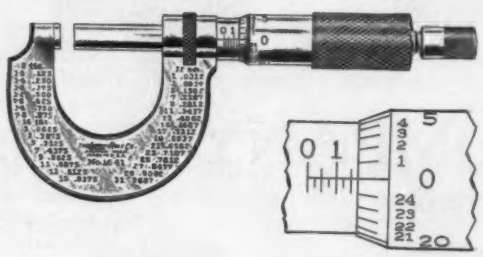
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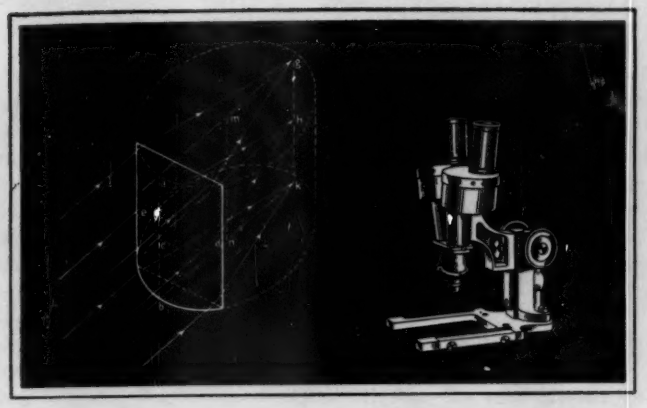

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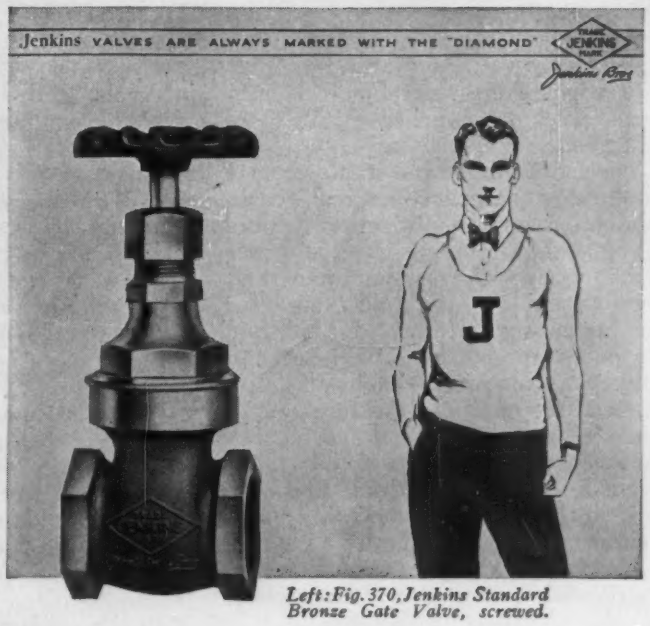

Left: Fig. 370, Jenkins Standard Bronze Gate Valve, screwed.

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(*Continued from page 141*)

to remove excess metal and lighten them, holes are punched in the spars and ribs.

The use of formed and stamped parts simplifying the operations required in fabrication, speeds production, for the forming and stamping is largely machine work. Sheet aluminum and aluminum alloys are widely used for making gas and oil tanks, for cowling, for floors, for covering fuselages and wings, and for many small parts. By corrugating the sheets, greater strength can be gained so that corrugated sheet metal construction has been applied. Corrugated dural has been used in the construction of wing spars, the spar being built up of two parallel corrugated strips a few inches apart, with braces riveted between at intervals, and the top and bottom pieces of rounded sheet dural riveted to the corrugated sides. Aluminum alloy castings, or heavy dural fittings, are placed where necessary for connection with the ship, and with flying and landing wires, struts, and braces. These castings have replaced a great many fittings formerly made from welded steel or riveted dural, as well as heavier castings of other metals sometimes used.

With the increasing production of airplanes, companies have appeared which specialize in manufacturing aeronautical accessories. It is possible today to buy dural made up into structural shapes particularly adapted to the requirements of airplane manufacture, with a considerable saving. Many manufacturers now purchase ready-made, finished, or rough parts which were formerly made at the airplane plant. Parts which all airplane manufacturing companies must use can be standardized and manufactured more cheaply by accessory companies. Among such parts are landing wheels, castings, tires, propellers, fabric, paints, dopes, steel and dural struts, motors, instruments, and electrical equipment.

In many cases, chrome-molybdenum steel tubing is used for airplane fuselages because it can be welded. Joint fittings are sometimes made up separately, and the tubing welded to these fittings often in a single welding operation. To secure the correct alignment, the tubing and fittings are set up in a large jig.

Some companies make use of metal fuselages, but retain the wooden wing construction, and others claim that plywood construction used for both fuselage and wings is the equal and superior to metal construction in many ways. It is said that plywood construction requires little maintenance work, and that wings covered with veneer need not be recovered, as is the case with fabric-covered wings. Plywood is generally made of layers of spruce and mahogany in varying thicknesses, glued together to form one piece, which has great strength. Plywood fuselages have been made with but little internal bracing, the plywood itself supplying all the needed strength. Plywood, together with spruce, is almost universally used in making wooden ribs, and in some ships, plywood beams are used in the wings.

In the new type of airplanes being manufactured for commercial purposes, safety and comfort are stressed. In military machines, a certain percentage of safety is sacrificed for maneuverability, and comfort is secondary to the most effective design of plane and arrangement of equipment with which to defeat the enemy. Commercial planes built especially for passenger carrying have large cabins, large windows, good lighting, heating, and ventilating to insure the comfort of the passengers, while some planes have berths so that it is possible for passengers to make night journeys with all of the convenience of a Pullman car.

Improvements are constantly being made which increase the safety of air travel. Three motors are generally used for large passenger planes, thus insuring flight in the event of the failure of one of the motors. Structural failure is rare with planes being built today. The dangers of fire are reduced with fire fighting apparatus controllable from the pilot's seat, and he can also dump the gasoline carried by the plane, through dump valves in the bottom of the tanks, or with apparatus permitting the dropping of the entire tank. With the development of the heavy oil Diesel engine for aircraft, the danger from fire will become extremely small. Modern airplanes are built to last for a longer time and to stand greater shocks than ever before, while government inspection allows only those planes which are in perfect condition, and are piloted by experienced pilots to carry passengers. With increasing production and more experimental work, greater safety will steadily be attained.

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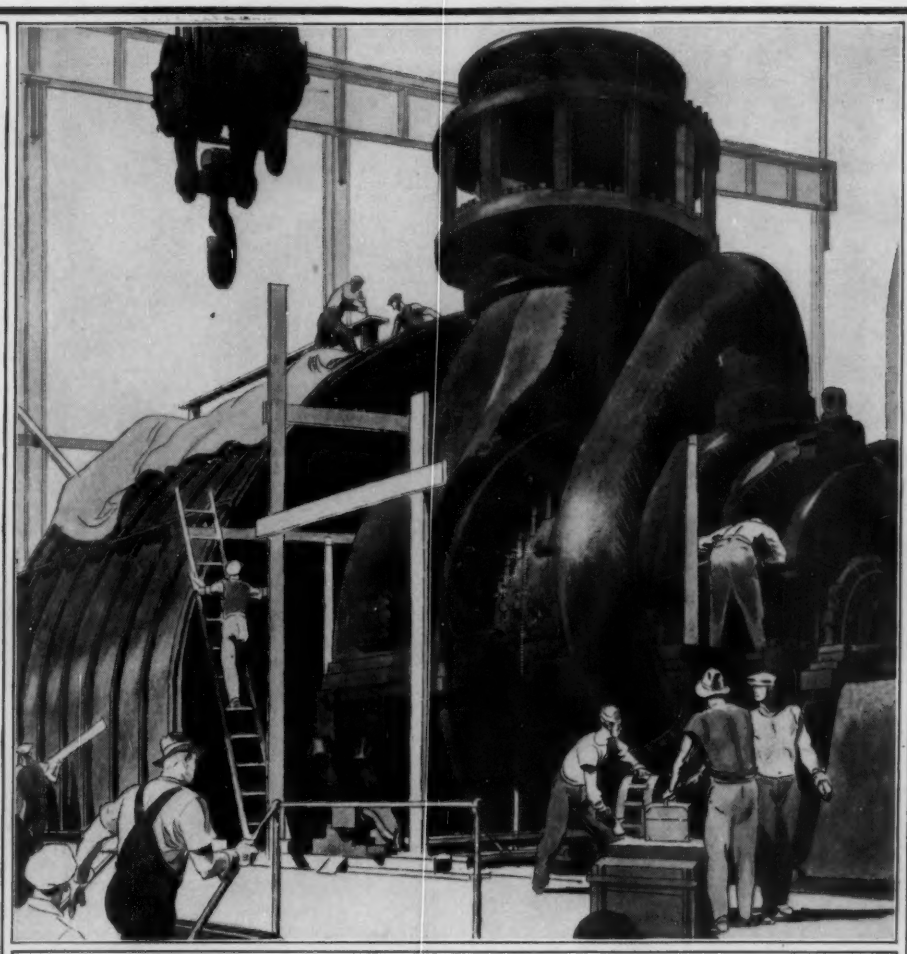

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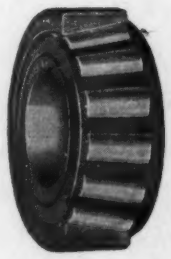

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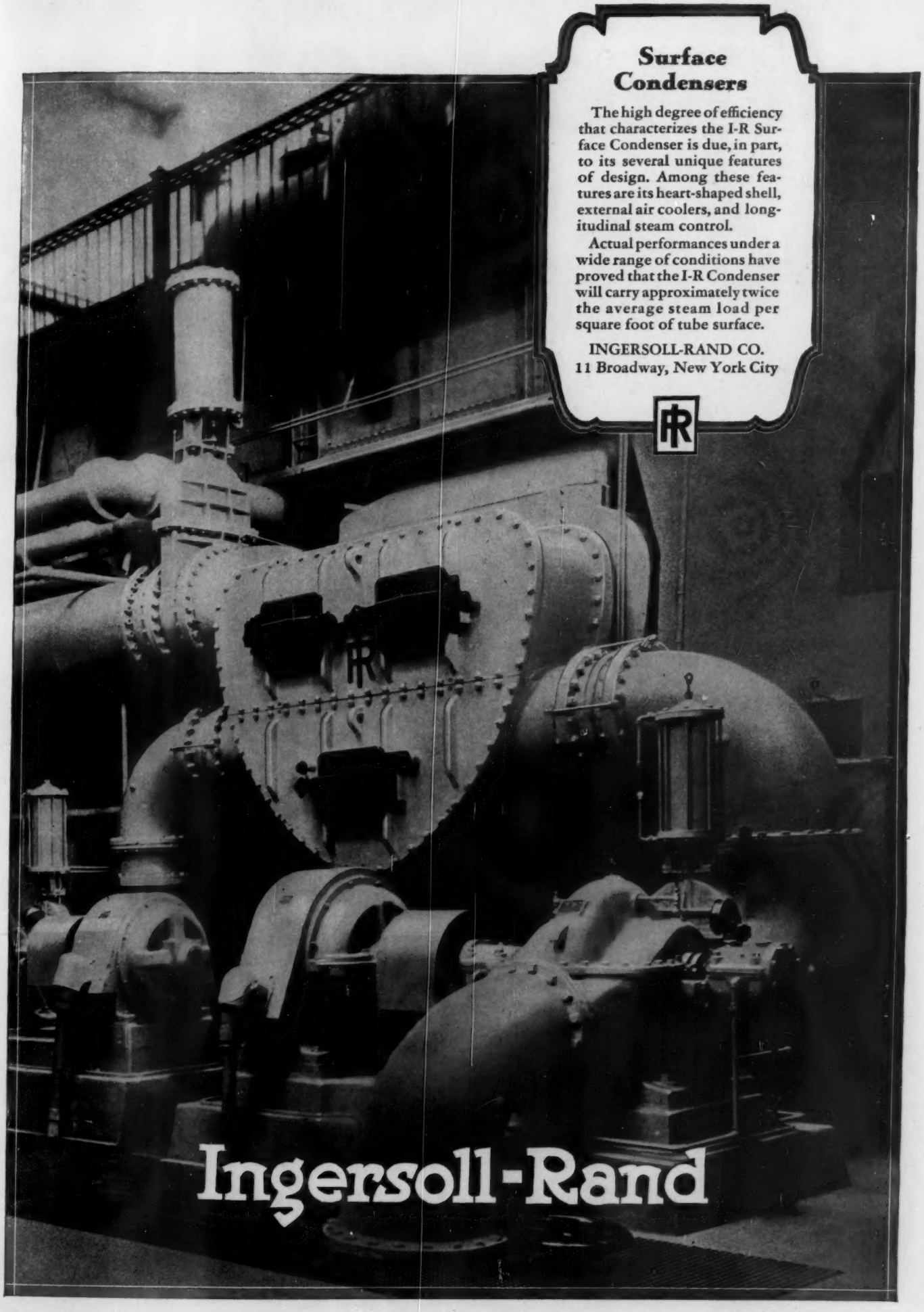

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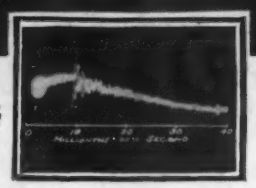
Man's hand upon the Lightning



The cathode-ray oscillogram of the induced lightning surge

NOT yet is the lightning tamed. But the hand of science reaches forth. Already a way has been found to make the lightning write its own record of this destructive force measured in millions of horsepower, which is still the greatest enemy of high-voltage transmission lines.

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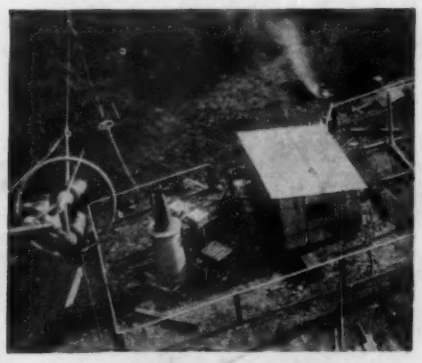

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